TR-161

TECHNICAL REPORT

GEOMAGNETIC AND BATHYMETRIC PROFILES ACROSS THE NORTH ATLANTIC OCEAN

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ABSTRACT

This report presents total magnetic intensity and bathymetric data collected on simultaneous North Atlantic crossings. Three ships, USNS BOWDITCH, USNS DUTTON, and USNS MICHELSON participated in the survey operations. These ships were equipped with nuclear resonance magnetometers and precision depth recorders. A combined total of approximately 17,200 miles of track was surveyed. The data presentation is in profile form and is divided into two parts. Part I presents the data from the westbound crossing between the Norwegian Sea and New York, and Part II presents the data from the eastbound crossing.

FOREWORD

In the mid-1950's, the Hydrographic Office--now the Oceanographic Office--initiated a program for conducting geomagnetic measurements at sea. A major part of this program involves conducting total magnetic intensity surveys aboard "ships of opportunity" while these ships are engaged in some primary tactical or logistics mission. This report presents geomagnetic and bathymetric data from such a survey. Much data of this type will be required for an accurate interpretation of the geologic and structural character of the ocean basins. This report is presented to help advance an understanding of these vast areas.

DENYS W. KNOLL
Rear Admiral, U. S. Navy
Commander

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TABLE

I. INTRODUCTION

In November 1961, three oceanographic survey ships--USNS BOWDITCH (T-AGS 21), USNS DUTTON (T-AGS 22), and USNS MICHELSON (T-AGS 23)--returned to New York from survey operations in the Norwegian Sea. This voyage provided the Oceanographic Office an unusual opportunity to collect magnetic and bathymetric data during multi-ship survey operations. The three ships returned to the Norwegian Sea in March 1962, and again magnetic and bathymetric measurements were taken concurrently.

This report presents the magnetic data obtained on these North Atlantic crossings. Bathymetric data are included for direct comparison between magnetic and topographic features. The data presentation is in profile form and is divided into two parts. Part I presents the data from the westbound crossing between the Norwegian Sea and New York; Part II presents the data from the eastbound crossing. In Part I, the profiles observed concurrently by each of the three ships during the westbound crossing are presented together on the same pages. This type of presentation was arranged so that any trends could be observed readily. In Part II, profiles from the BOWDITCH and DUTTON also are presented on the same pages. The MICHELSON data, however, are presented separately because the MICHELSON route on the return crossing differed considerably from the routes of the other two ships.

The amount of data contained in this report is so extensive that a complete analysis would make it unavailable for a long time. Therefore, no analysis or interpretation is presented in this report.

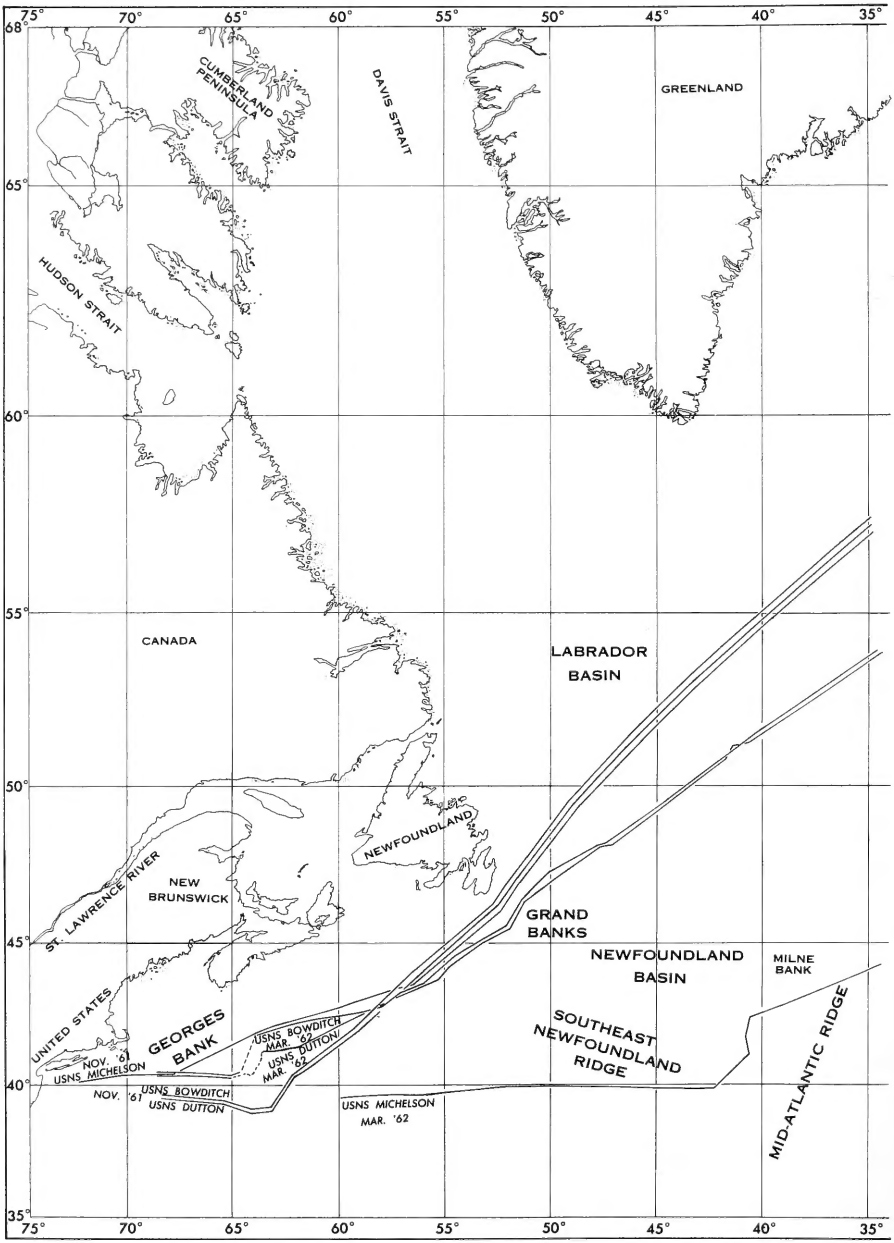
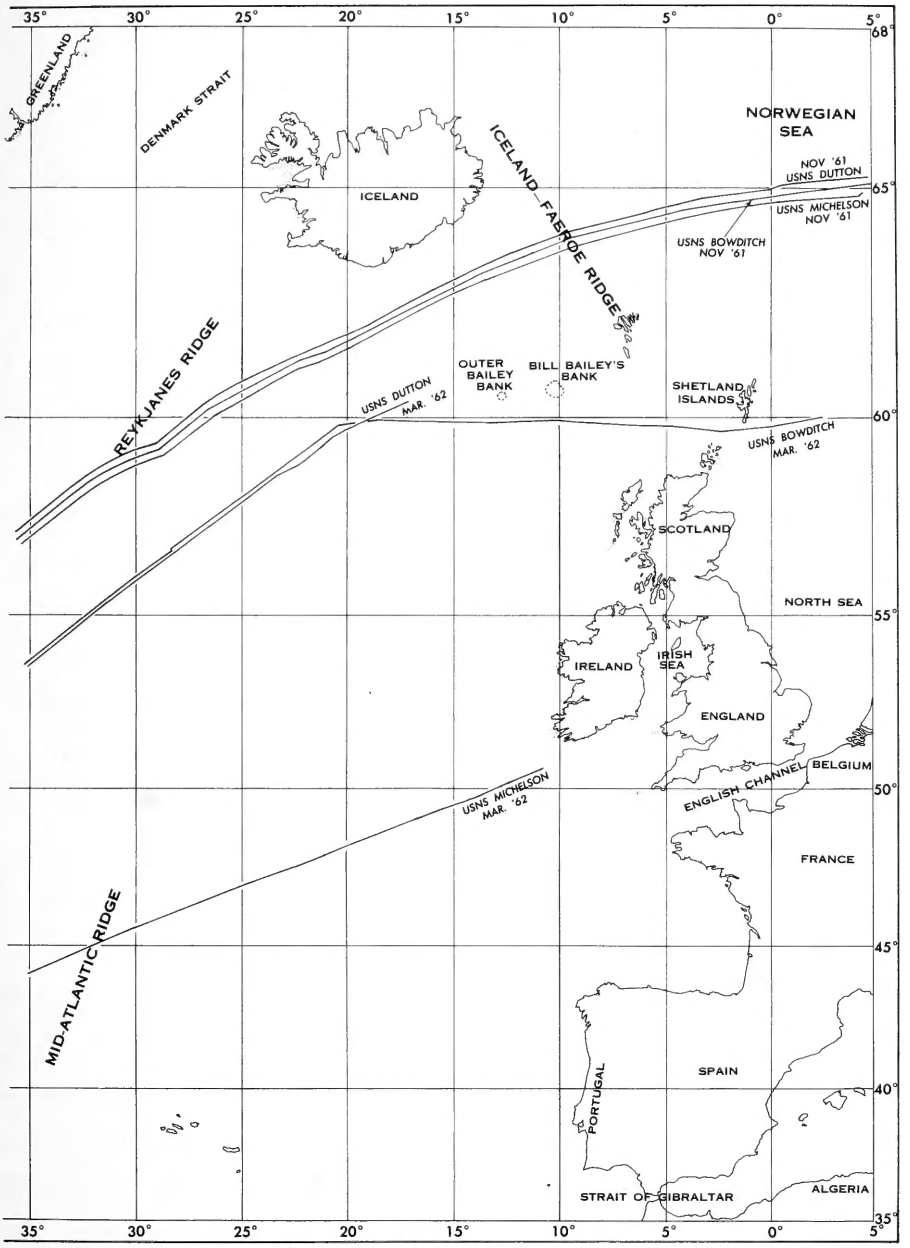


FIGURE 1.— TRACK CHART


35°
30°
25°
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15°
10°
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65°
60°
55°
50°
45°
40°
35°
GREENLAND
DENMARK STRAIT
ICELAND
NORWEGIAN SEA
ICELAND-FAEROE RIDGE
NOV '61
USNS DUTTON
USNS MICHELSON
NOV '61
USNS BOWDITCH
NOV '61
REYKJANES RIDGE
OUTER BAILEY BANK
BILL BAILEY'S BANK
SHETLAND ISLANDS
USNS DUTTON
MAR. '62
USNS BOWDITCH
MAR. '62
SCOTLAND
NORTH SEA
IRELAND
IRISH SEA
ENGLAND
BELGIUM
ENGLISH CHANNEL
USNS MICHELSON
MAR. '62
FRANCE
MID-ATLANTIC RIDGE
SPAIN
PORTUGAL
STRAIT OF GIBRALTAR
ALGERIA

II. SURVEY OPERATIONS

A. Conduct of Survey

1. Norwegian Sea - New York

The survey was conducted along tracks that correspond roughly to great-circle routes between the Norwegian Sea and New York. (Fig. 1) At 0330, 20 November 1961, the three ships rendezvoused in the Norwegian Sea. At this time, they formed a three-abreast array to be maintained during the Atlantic crossing. BOWDITCH assumed the center position and was responsible for setting the course and speed during the survey. DUTTON took a position 10 miles to the northward of BOWDITCH, and MICHELSON took a position 10 miles to the southward of BOWDITCH. These positions were maintained until 0900, 27 November. At that point, about 1200 miles from New York, MICHELSON developed boiler trouble and was unable to maintain survey speed. MICHELSON broke formation at 0230, 28 November, and set a direct course for New York. BOWDITCH and DUTTON continued in formation on a route south of Georges Bank. When the three ships arrived in New York on 1 December 1961, they had completed a combined total of approximately 9350 miles of survey track.

Adverse weather conditions prevailed during most of the crossing. Because of this, the ships' speeds varied from 12 to 17 knots. On a few occasions, the seas were too rough to tow the magnetometer sensing units. At 1100, 29 November, the magnetometer sensing unit towed by DUTTON was damaged because of constant jerking in heavy seas. A spare was available, but rough seas prevented launching during the remaining 300 miles of the trip.

2. New York - Norwegian Sea

After undergoing extensive overhaul, the three ships departed New York on 2 March 1962. BOWDITCH and DUTTON conducted survey operations similar to those of the westbound crossing. Again, their tracks corresponded roughly to great-circle routes between New York and the Norwegian Sea. DUTTON maintained a position 10 miles southward of BOWDITCH. MICHELSON's survey track, however, was considerably south of the other two ships' tracks and terminated south of Ireland. (Fig. 1.)

During these crossings, severe storms made it difficult for the ships to maintain their positions relative to each other. At times, the ships were forced to heave to, and the magnetometer sensing units were not towed. Consequently, there are several gaps in the magnetic profiles obtained during these crossings.

MICHELSON ended its survey track at 0100, 11 March, DUTTON at 0330, 12 March, and BOWDITCH at 1130, 13 March, after completing a three-ship total of approximately 7850 miles of eastbound survey tracks. During westbound and eastbound crossings, the three ships surveyed a combined total of approximately 17,200 miles of track.

B. Control

On those parts of the survey tracks lying in mid-ocean, survey control was by Loran-A, with occasional celestial fixes. Navigation in these areas was hampered considerably by the adverse weather conditions. Consequently, many of the positions were determined by dead-reckoning. For most of the track in midocean, the probable position error is within 5 miles and is at no time considered to be greater

than 10 miles. The position of each ship was determined at 15-minute time intervals and then plotted on Mercator Plotting Sheets (scale: 1^{o} longitude = 4 inches). Near land areas, Loran-C or Decca was usually available. Here the maximum position error is less than 1 mile. The relative positions of the ships were maintained by taking occasional radar ranges and bearings from one ship to another.

After completion of the survey, each ship's smooth-plotted survey track was transferred to a master set of plotting sheets. The best position fixes from each ship were combined with the intership radar range and bearing data. Consequently, the resulting adjusted tracks represent a compilation of the best possible positioning information.

C. Instrumentation

Each survey ship was equipped with a Varian nuclear resonance magnetometer, Model XN-4901. With this instrument, the absolute value of the total magnetic field intensity can be measured to an accuracy of about ± 1 gamma. The sensing unit was towed 500 feet astern to reduce the effect of the ship's magnetic field. Data were recorded on a Varian G-11 analog recorder in units of "magnetometer counts." These units, an inherent property of the magnetometer design, are an inverse function of the total magnetic field intensity.

Each ship also was equipped with a standard Edo AN/UQN Sonar set. Instrument output was recorded directly in fathoms on a Mark VI Precision Depth Recorder.

Greenwich Mean Time was used exclusively for all survey work. The time marks for both the magnetometer and the Precision Depth Recorder were provided automatically by a central clock on each ship.

III. DATA PROCESSING

A. Preliminary Data Processing

Magnetometer records were scaled at 50-gamma intervals and also at times when maximum and minimum values of magnetic intensity were recorded. Gamma values were obtained by using a scaling template designed for converting magnetometer counts to gammas.

Precision Depth Recorder traces were scaled directly at 100-fathom intervals and also for maximum and minimun recorded depths. No sound-velocity or other corrections have been applied to the bathymetric data.

Magnetic and bathymetric profiles for each of the three ships were constructed using the adjusted survey tracks as base lines. An index to the geographical location of each profile is given in Figure 2, Part I (Norwegian Sea - New York), and in Figure 31, Part II (New York - Norwegian Sea). Profiles in Part I are presented in reverse numerical sequence from west to east to provide a more effective presentation. Adjusted smooth plots of the survey tracks are shown on the upper portions of the profile sheets.

B. Magnetic Temporal Variations

The magnetic data were not corrected for temporal variations of the earth's magnetic field; however, records from the magnetic observatories at Fredericksburg, Virginia, and Hartland, England, were studied to determine if there were any unusual magnetic disturbances during the Atlantic crossings.

The records obtained from each observatory were in the form of the 3-hour, magnetic K-index. Conventionally, the K-index is a digit

from 0 to 9. These digits indicate the difference between maximum and minimum values of one of the magnetic vector components occurring during specified 3-hour time intervals. Table I lists the gamma ranges for the K-index values at Fredericksburg and Hartland.

The K-indices from each observatory are given in graphical form in Figures 3 and 32 appearing at the beginning of Parts I and II respectively. It should be noted that the records from these two observatories represent geomagnetic conditions existing within only a few miles of their respective geographic locations. These records can, however, give an indication of conditions that probably occurred in areas adjacent to the observatories.

Figure 3 shows that during the November 1961 crossing, the K-index values from Fredericksburg exceeded index 3 (40 gammas) for only one 3-hour interval, 0600-0900, 20 November. During this interval, however, the survey ships were nearer to Hartland than to Fredericksburg. The Hartland values never exceeded index 3 during the entire time of the westbound crossing.

Figure 32 reveals that geomagnetic conditions were more disturbed during the March 1962 crossing. On 5 and 6 March, K-indices exceeded index 3 at both observatories. The values from Hartland again exceeded index 3 on 10, 12, and 13 March. At no time during westbound or eastbound crossings did the K-index values of either observatory exceed index 5 (120 gammas). It is assumed, therefore, that no significant temporal anomalies are incorporated in the magnetic data profiles.

TABLE I

GAMMA RANGES FOR K-INDICES

Fredericksburg and Hartland Magnetic Observatories

K-INDEX	GAMMA RANGES
0	0-5
1	5-10
2	10-20
3	20-40
4	40-70
5	70-120
6	120-200
7	200-330
8	330-500
9	500-Up

IV. DATA PRESENTATION

PART I: NORWEGIAN SEA - NEW YORK

(FIGS. 2-30)

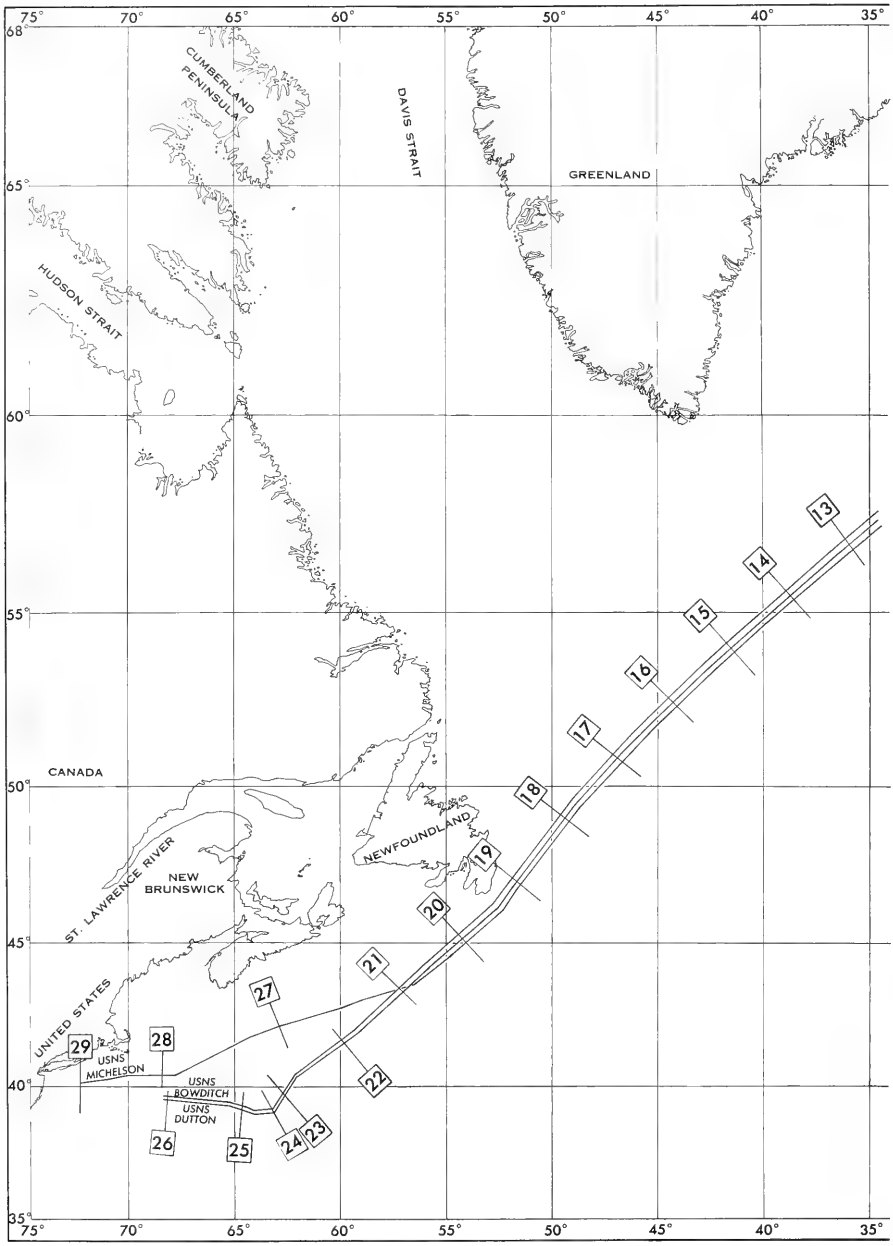
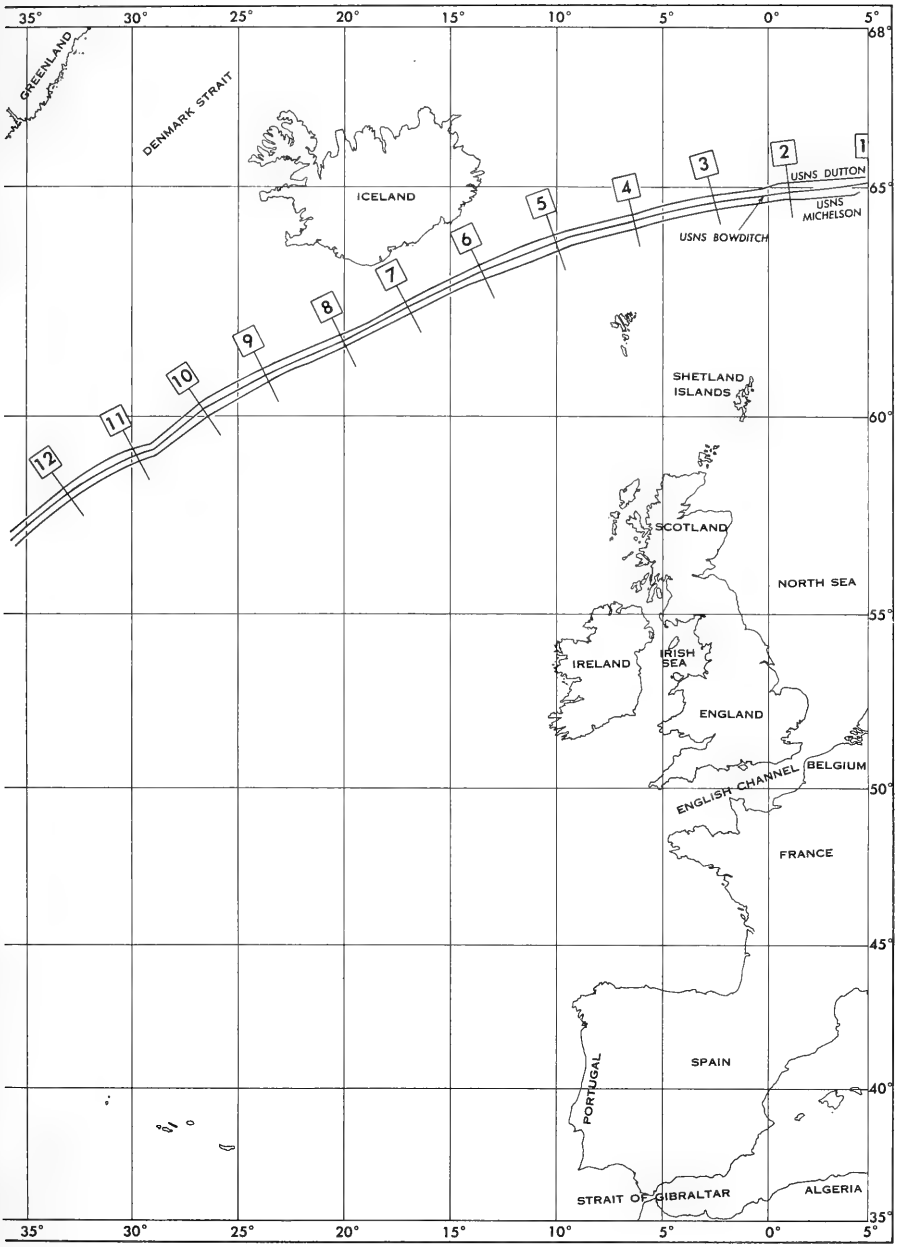


FIGURE 2.— PROFILE INDEX NORWEGIAN SEA—NEW YORK


35°
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0°
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68°
65°
60°
55°
50°
45°
40°
35°
GREENLAND
DENMARK STRAIT
ICELAND
1
2
3
4
5
6
7
8
9
10
11
12
USNS DUTTON
USNS MICHELSON
USNS BOWDITCH
SHETLAND ISLANDS
SCOTLAND
NORTH SEA
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ENGLISH CHANNEL
FRANCE
SPAIN
PORTUGAL
STRAIT OF GIBRALTAR
ALGERIA

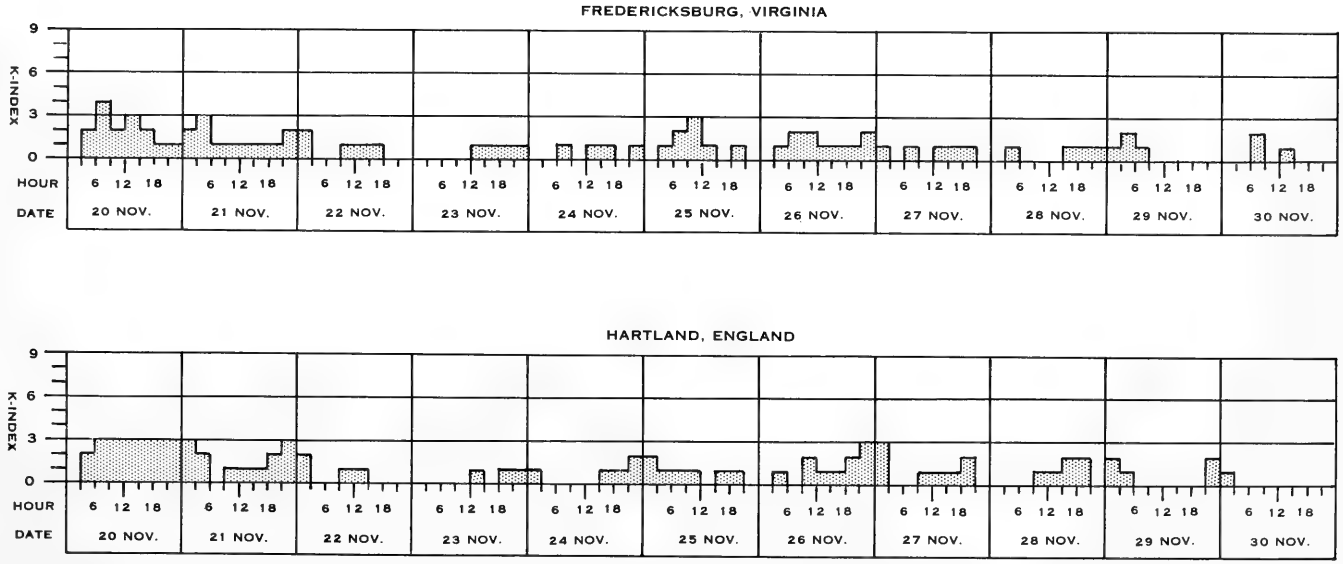


FIGURE 3.—K-INDICES OF GEOMAGNETIC ACTIVITY

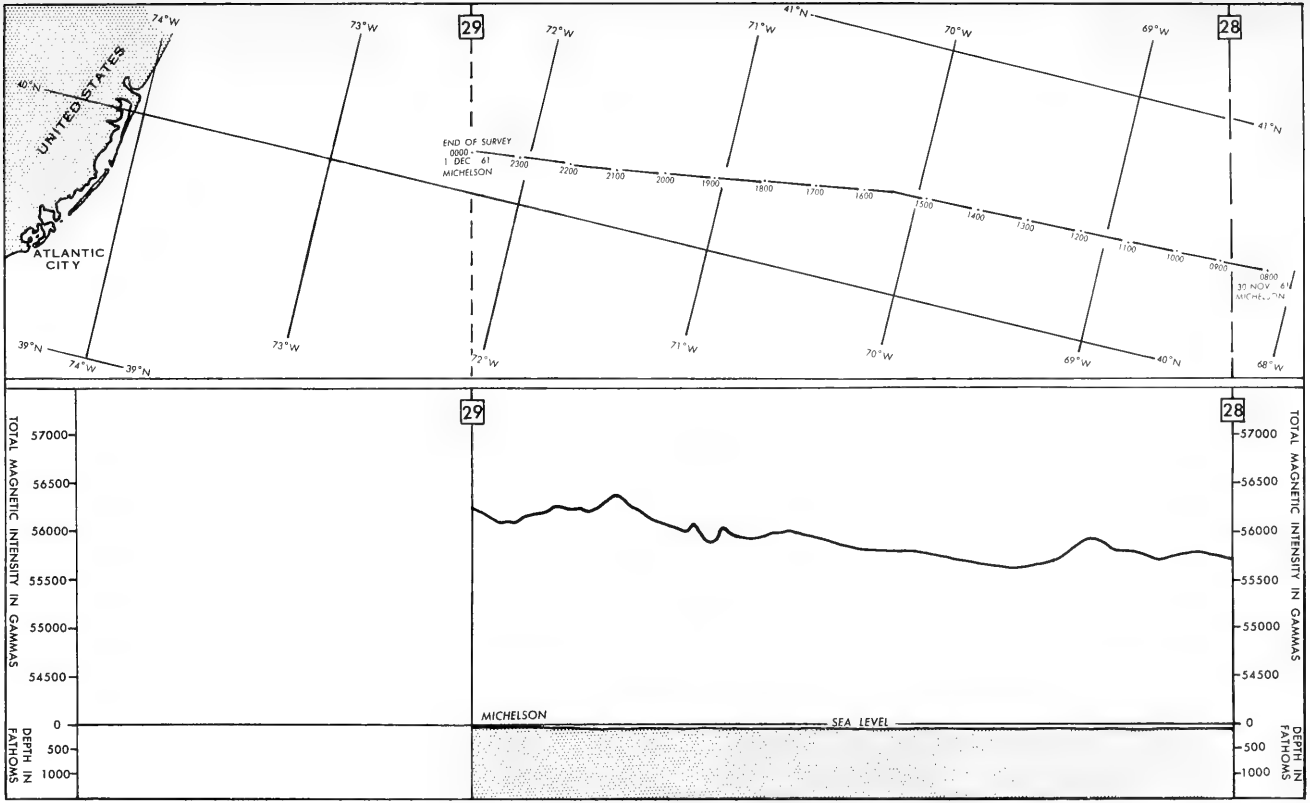
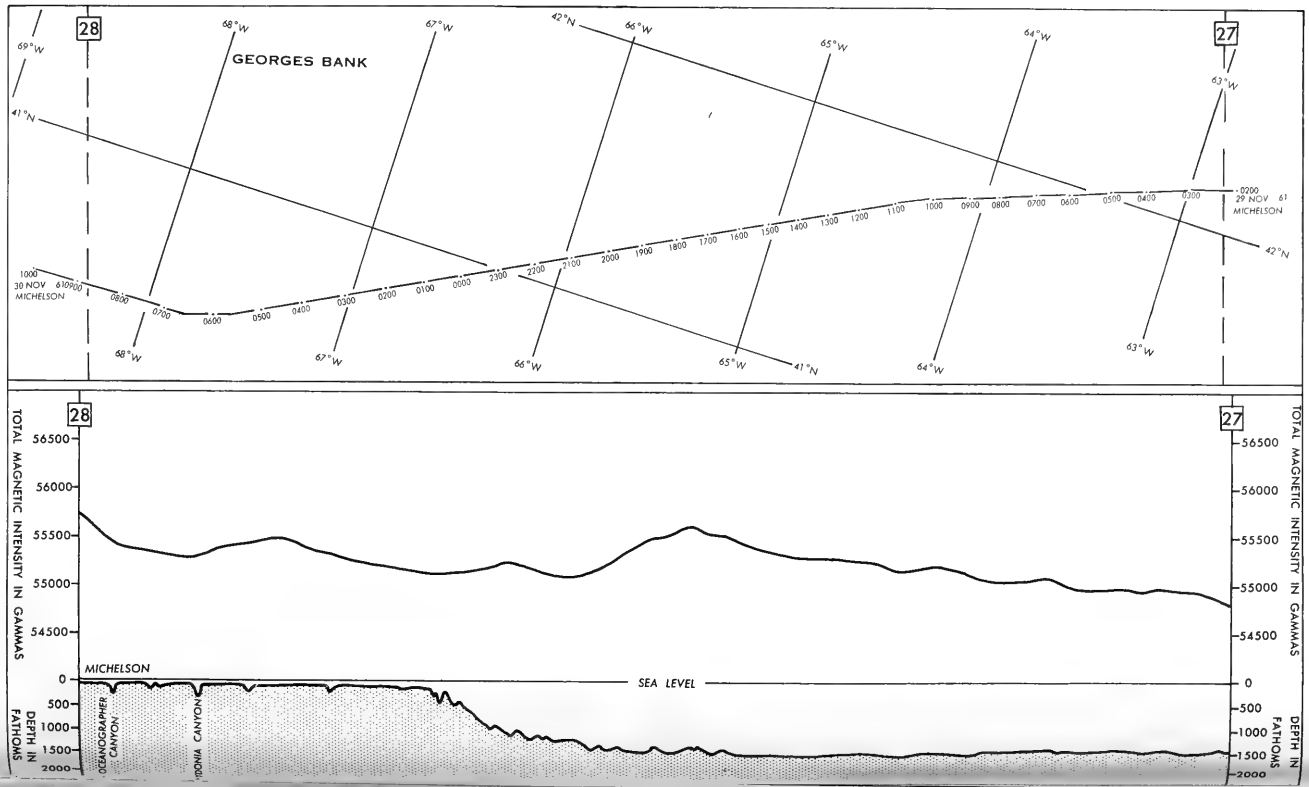


FIGURE 4.— MAGNETIC AND BATHYMETRIC PROFILES 28-29

10 5 0 10 20 30 NAUTICAL MILES


28
27
GEORGES BANK
69°W
68°W
67°W
66°W
65°W
64°W
63°W
41°N
42°N
1000
30 NOV 61
MICHELSON
0200
29 NOV 61
MICHELSON
TOTAL MAGNETIC INTENSITY IN GAMMAS
56500
56000
55500
55000
54500
MICHELSON
SEA LEVEL
DEPTH IN FATHOMS
0
500
1000
1500
2000
OCEANOGRAPHER CANYON
DOHNA CANYON

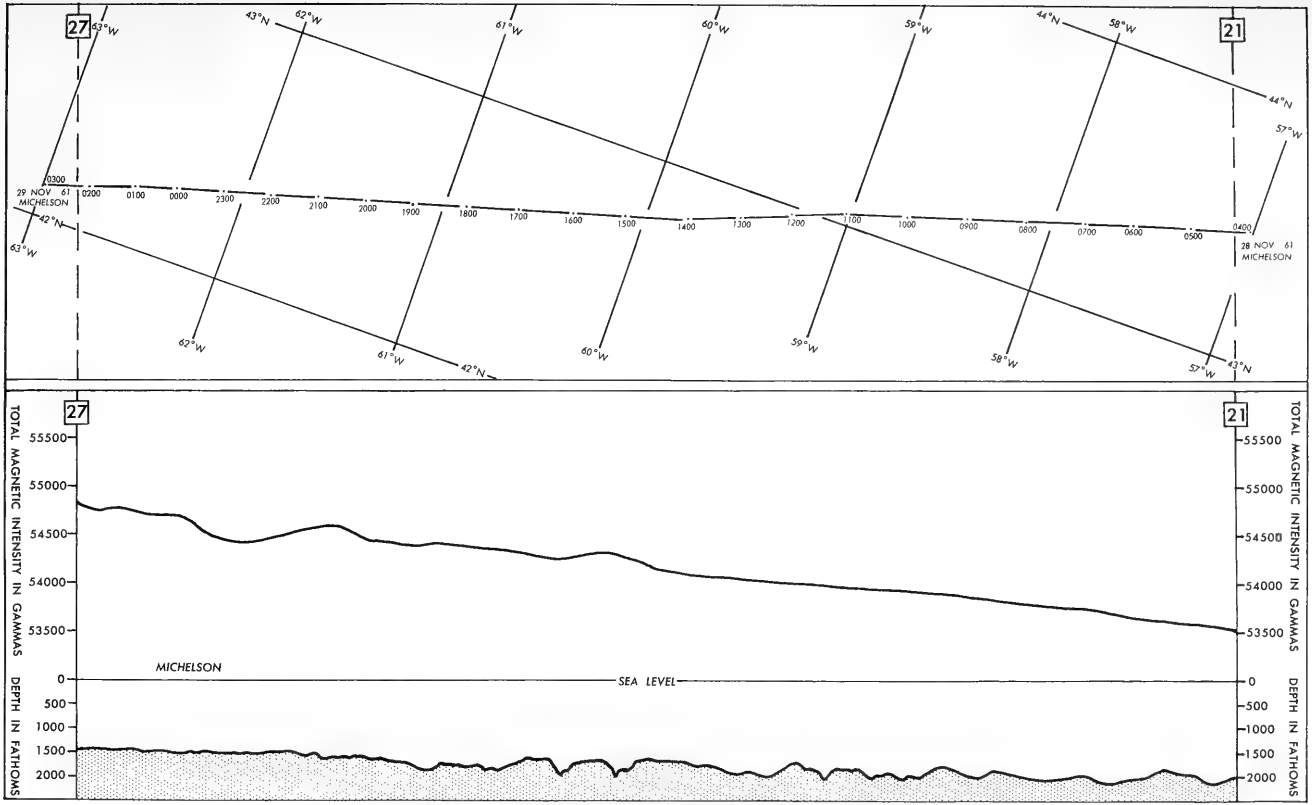


FIGURE 6.— MAGNETIC AND BATHYMETRIC PROFILES 21-27

10 5 0 10 20 30
NAUTICAL MILES

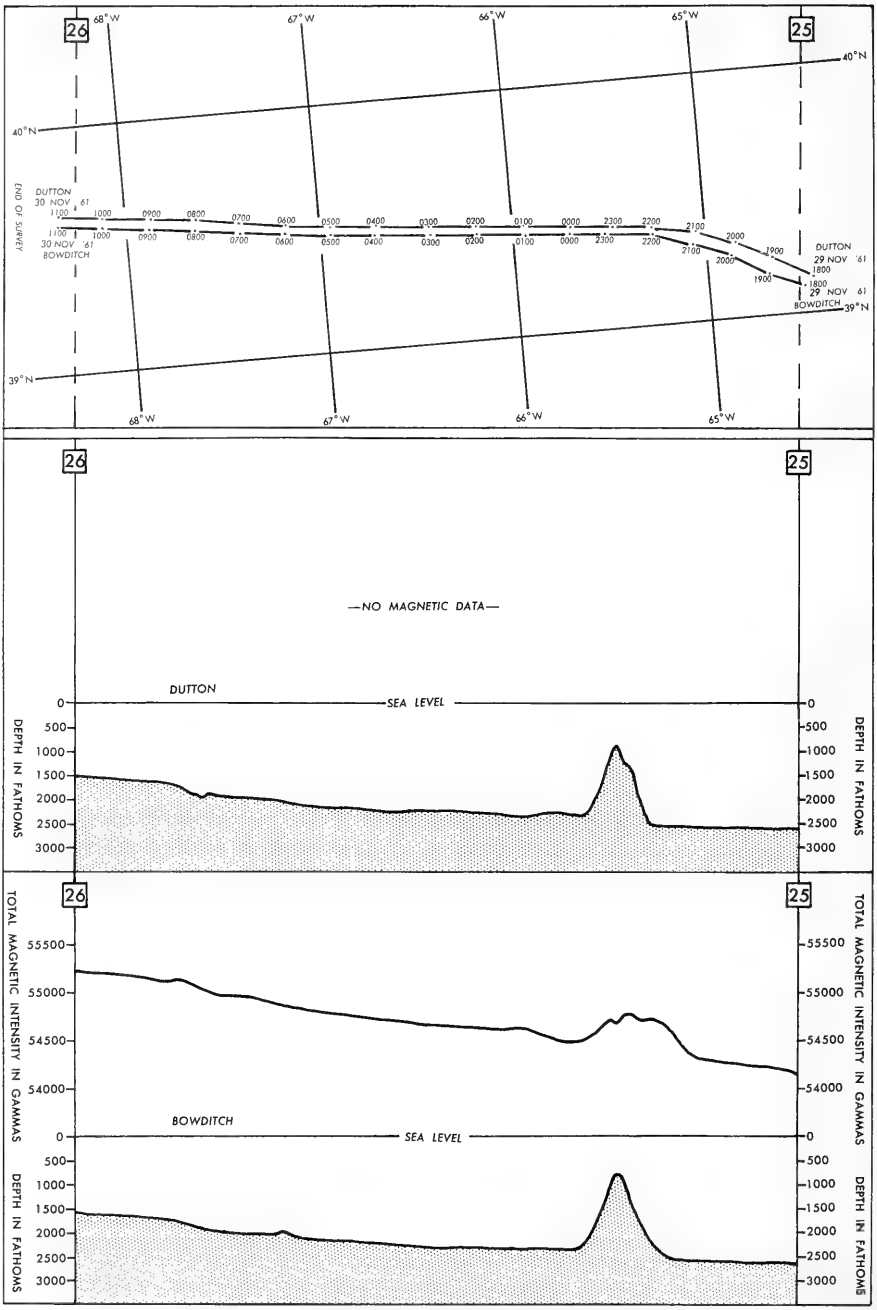


FIGURE 7.— MAGNETIC AND BATHYMETRIC PROFILES 25-26

10 5 0 10 20 30 NAUTICAL MILES

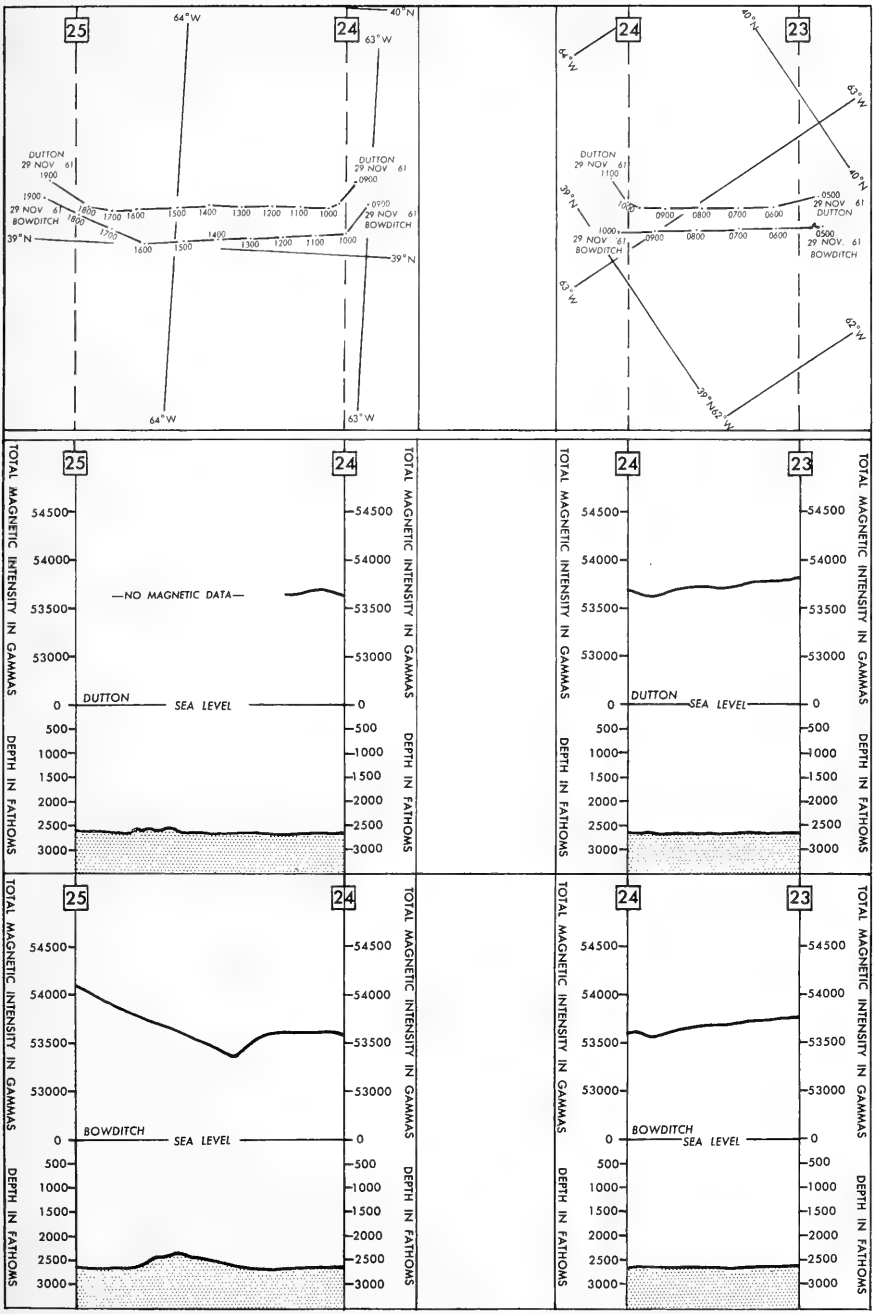


FIGURE 8.— MAGNETIC AND BATHYMETRIC PROFILES 23-24 AND 24-25

10 5 0 10 20 30 NAUTICAL MILES

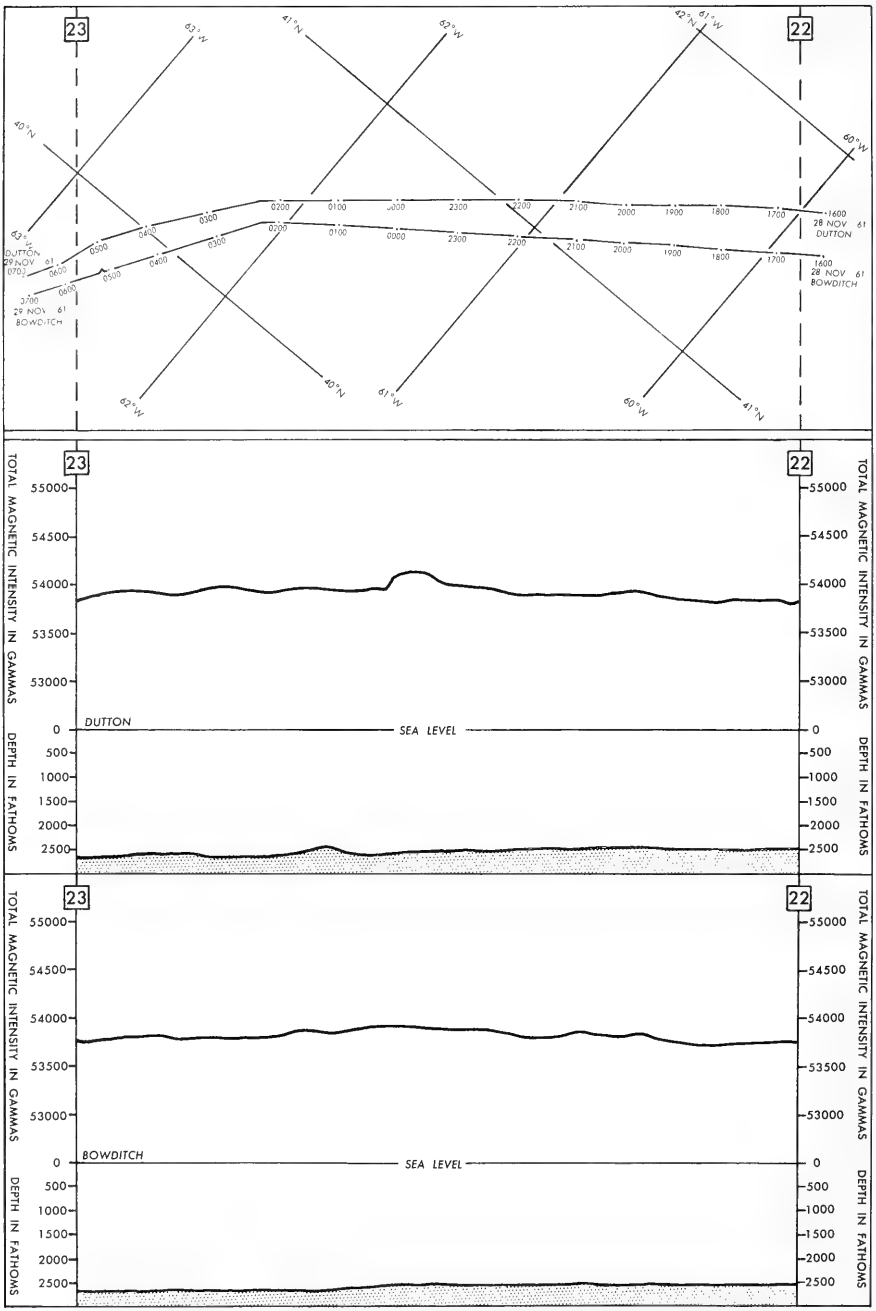


FIGURE 9.— MAGNETIC AND BATHYMETRIC PROFILES 22-23

10 5 0 10 20 30 NAUTICAL MILES

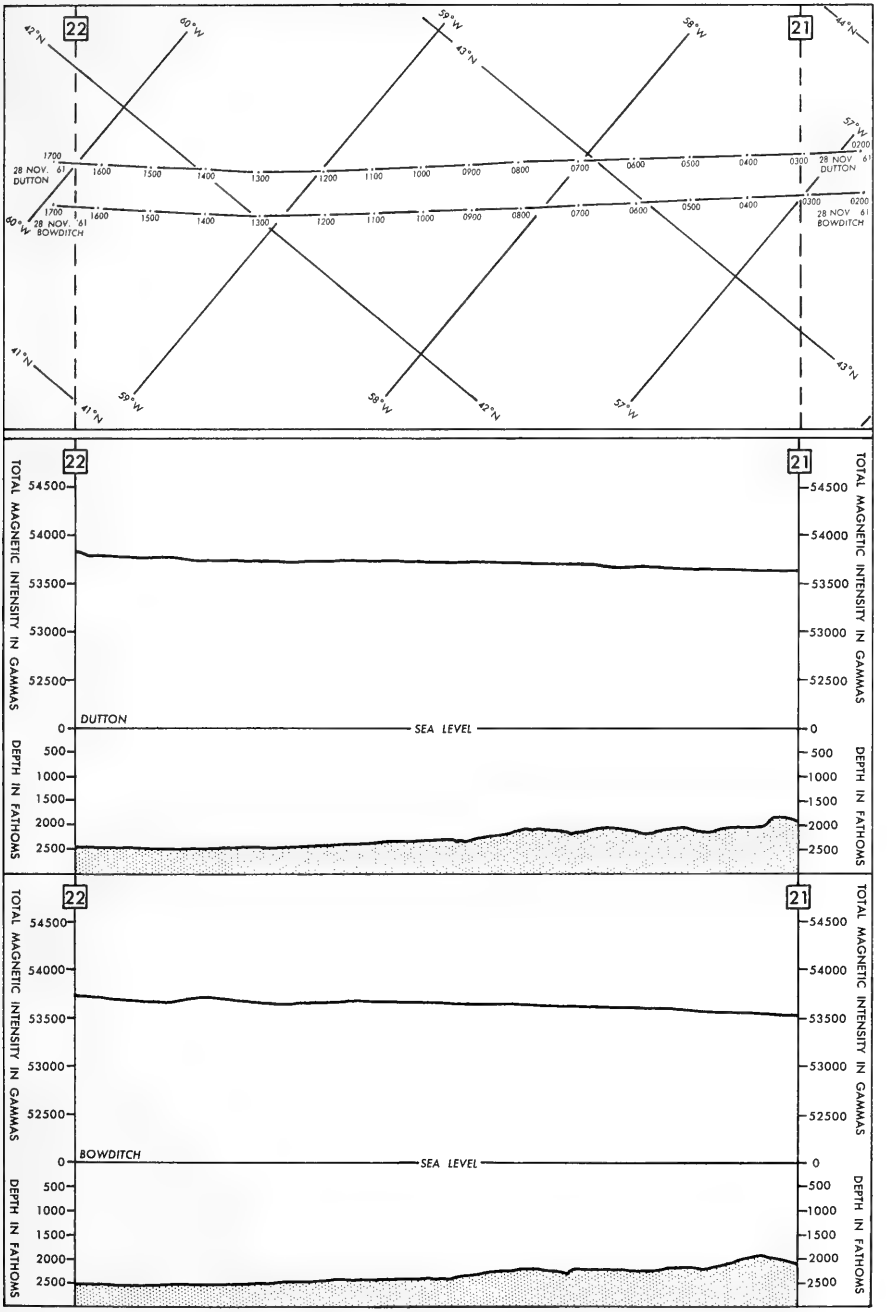


FIGURE 10.— MAGNETIC AND BATHYMETRIC PROFILES 21-22

10 5 0 10 20 30 NAUTICAL MILES

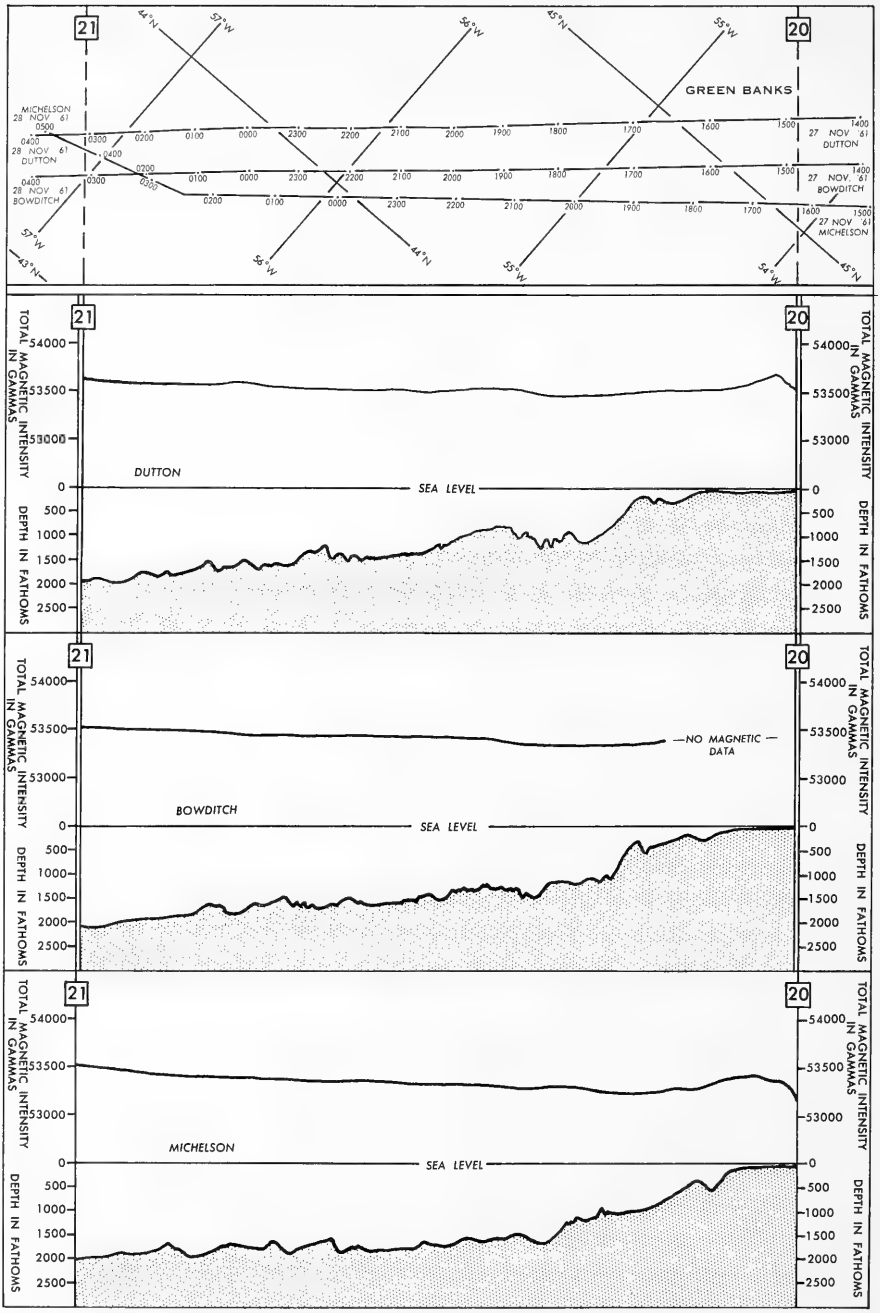


FIGURE 11.— MAGNETIC AND BATHYMETRIC PROFILES 20-21

10 5 0 10 20 30
NAUTICAL MILES

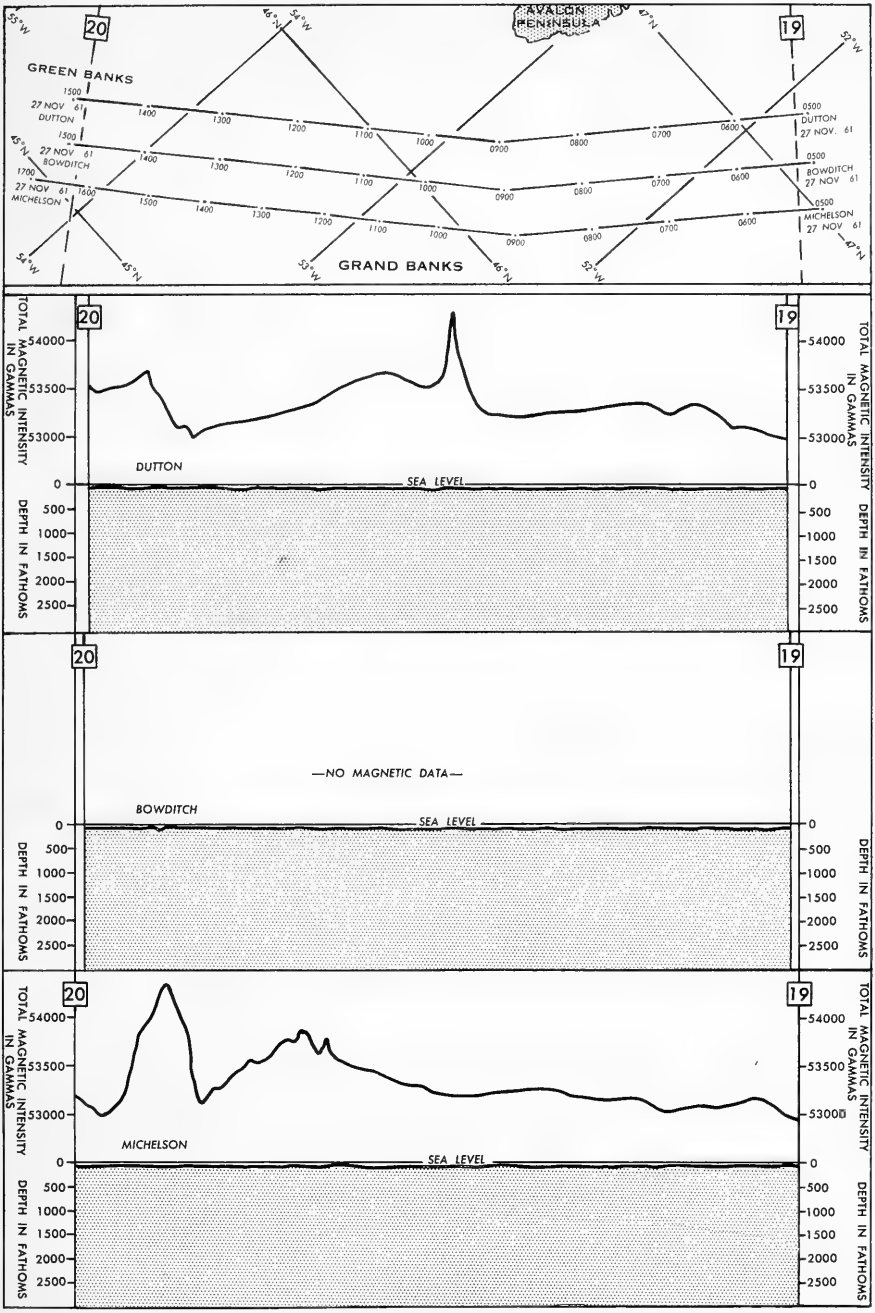


FIGURE 12.— MAGNETIC AND BATHYMETRIC PROFILES 19-20

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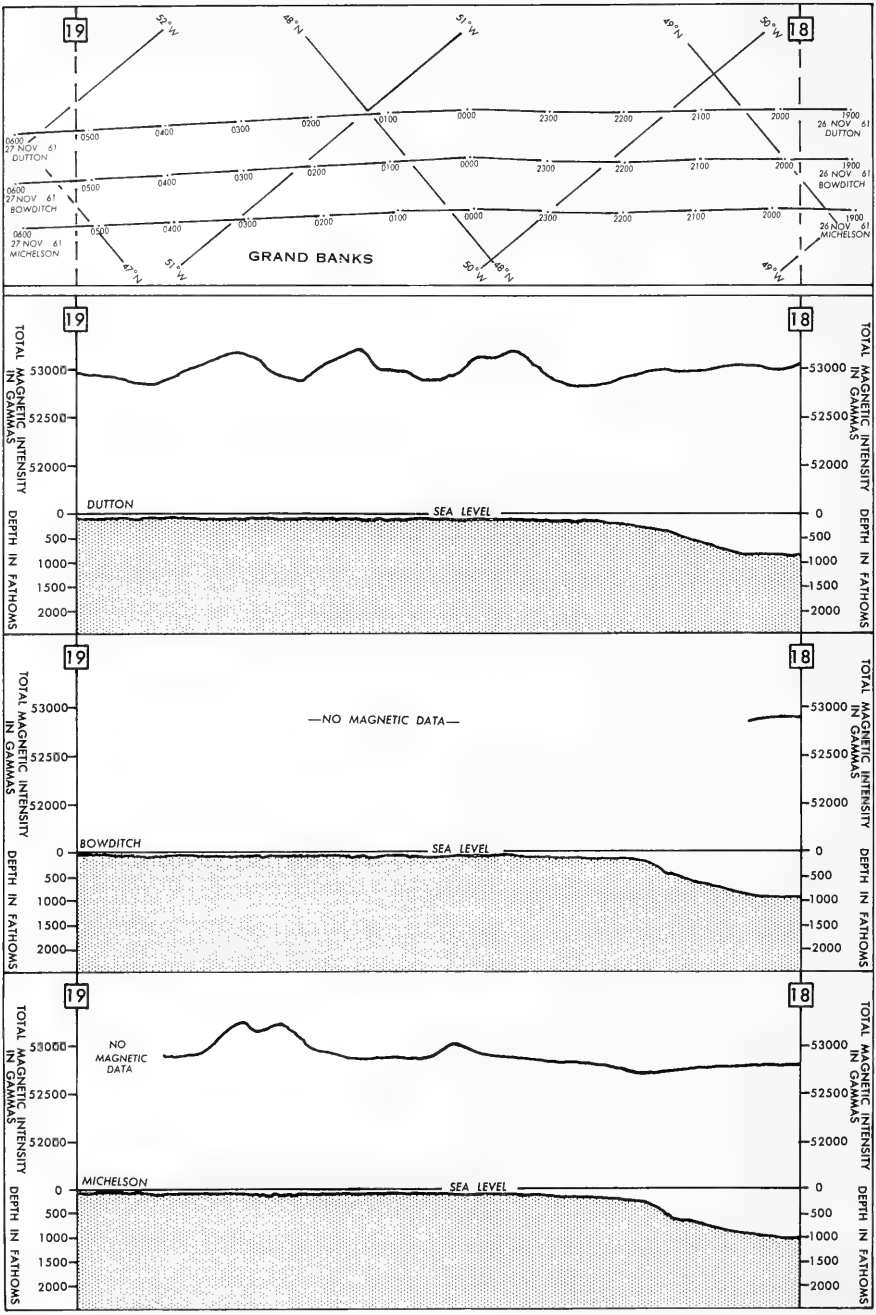

FIGURE 13.— MAGNETIC AND BATHYMETRIC PROFILES 18-19

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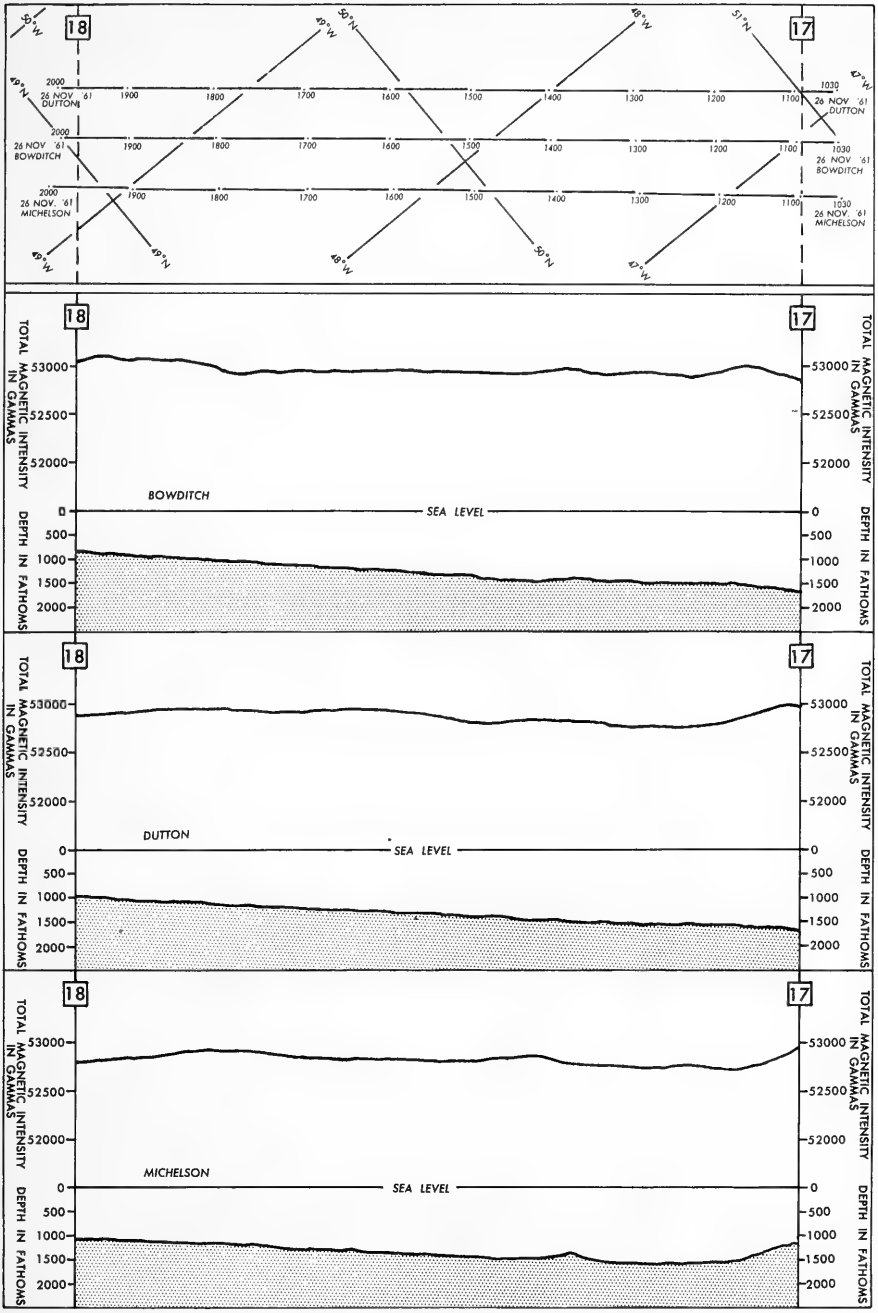

FIGURE 14.—MAGNETIC AND BATHYMETRIC PROFILES 17-18

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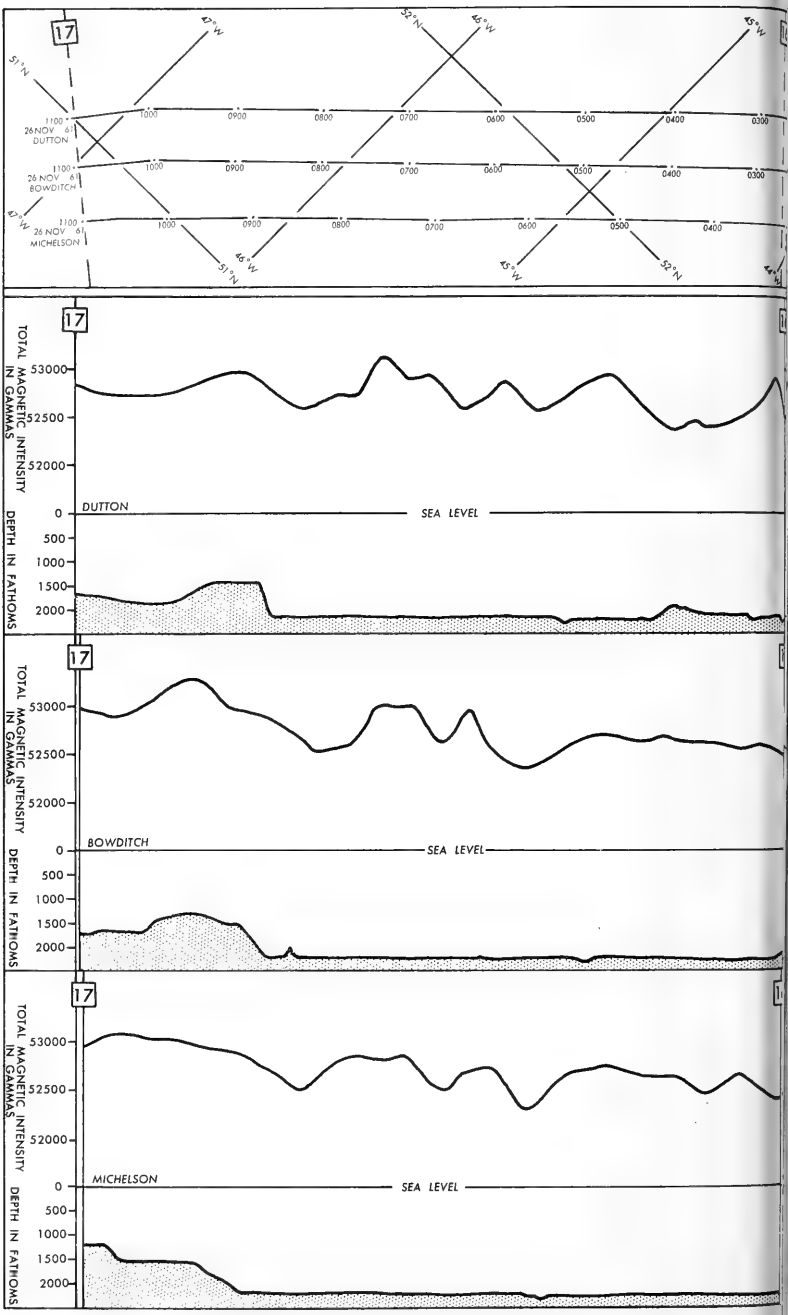

FIGURE 15.— MAGNETIC AND BATHYMETRIC PROFILES 16-17

10 5 0 10 20 30 NAUTICAL MILES

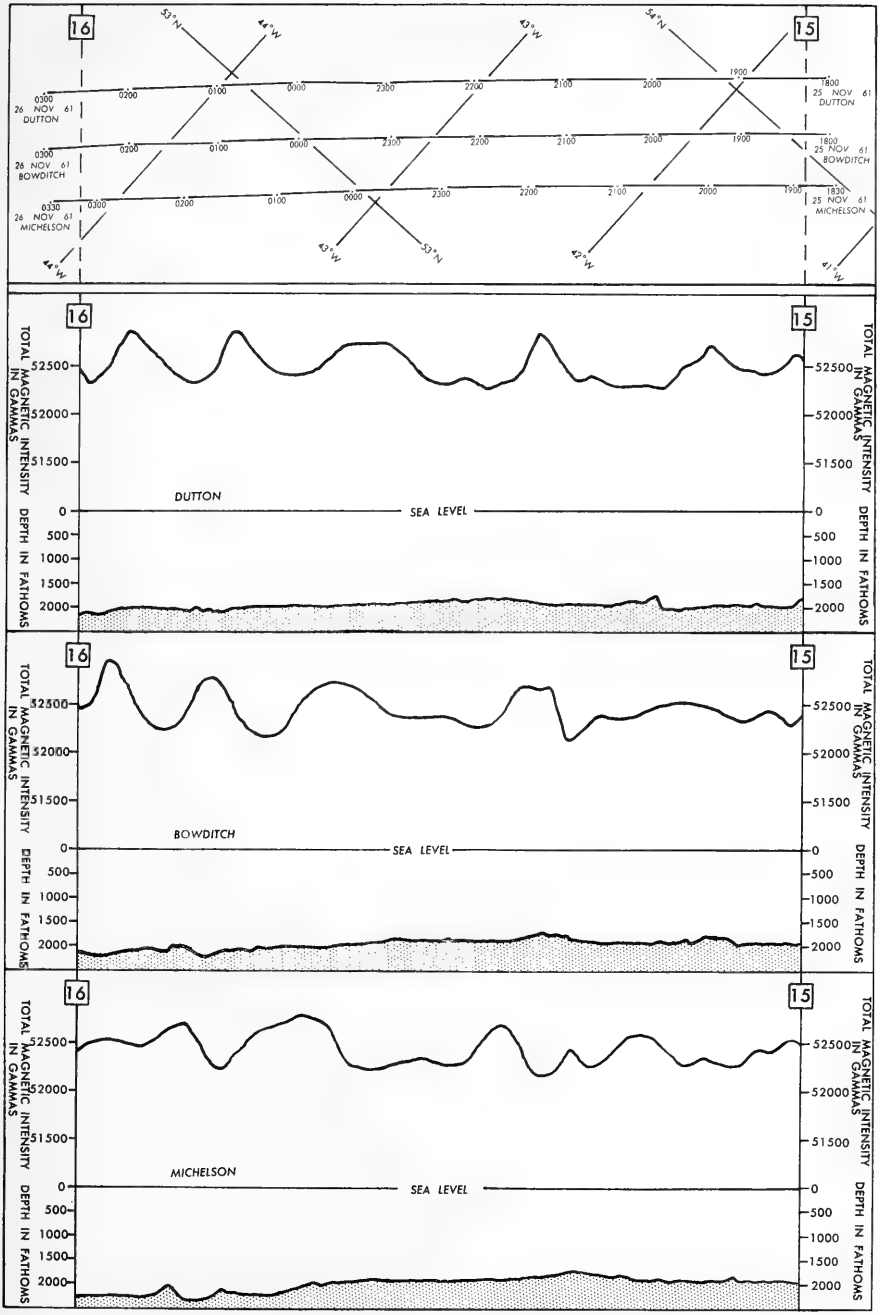

FIGURE 16.— MAGNETIC AND BATHYMETRIC PROFILES 15-16

10 5 0 10 20 30 NAUTICAL MILES

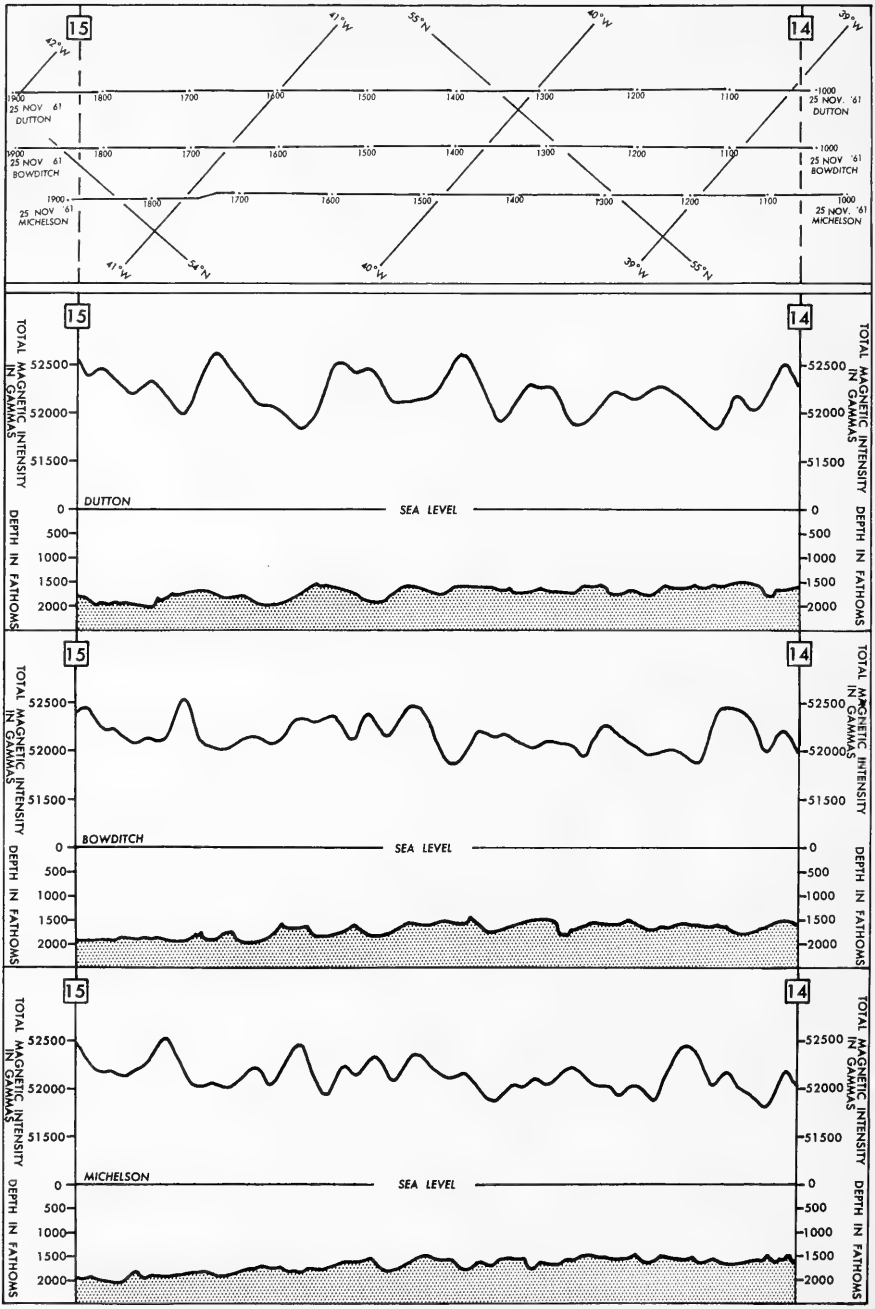

FIGURE 17.— MAGNETIC AND BATHYMETRIC PROFILES 14-15

10 5 0 10 20 30 NAUTICAL MILES

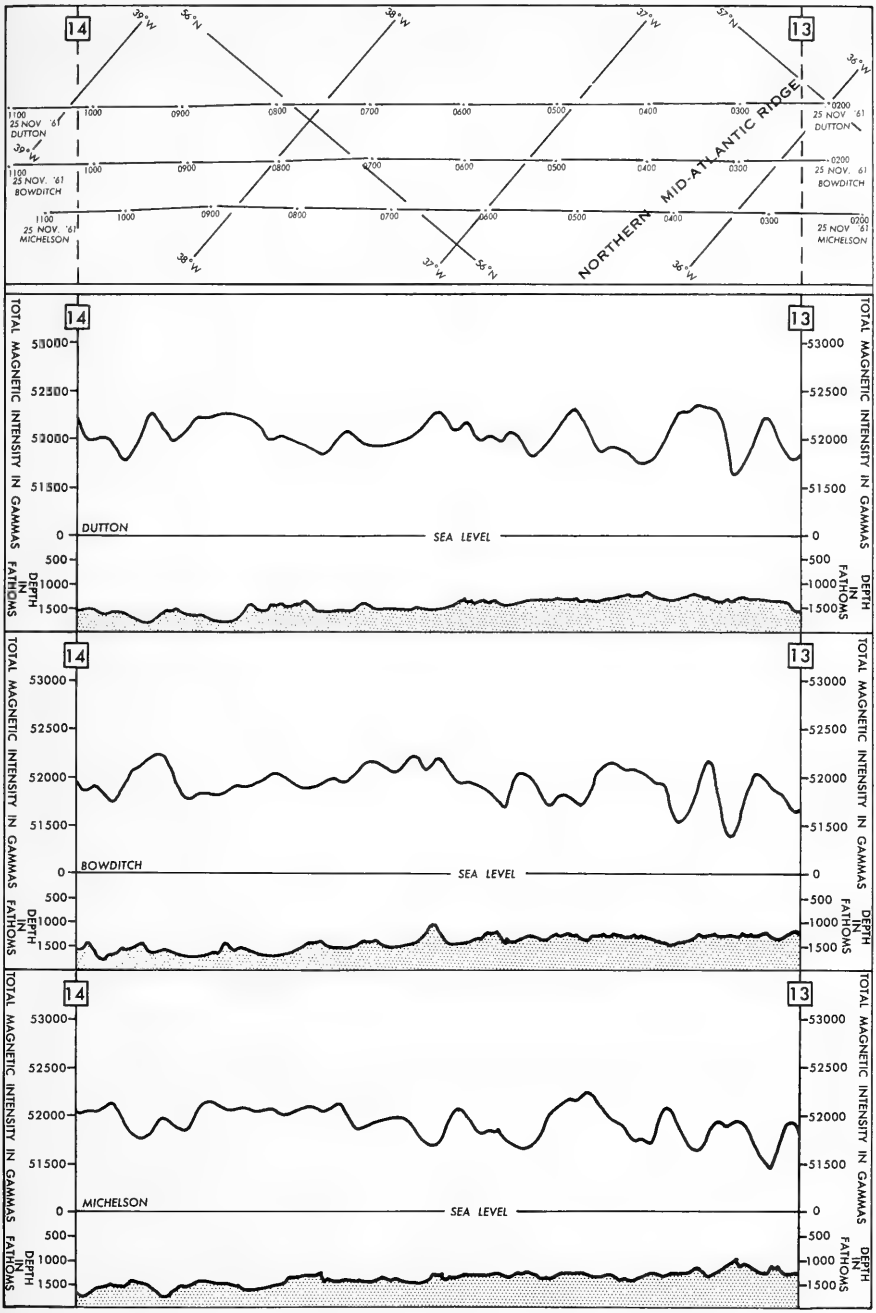

FIGURE 18.— MAGNETIC AND BATHYMETRIC PROFILES 13-14

10 5 0 10 20 30 NAUTICAL MILES

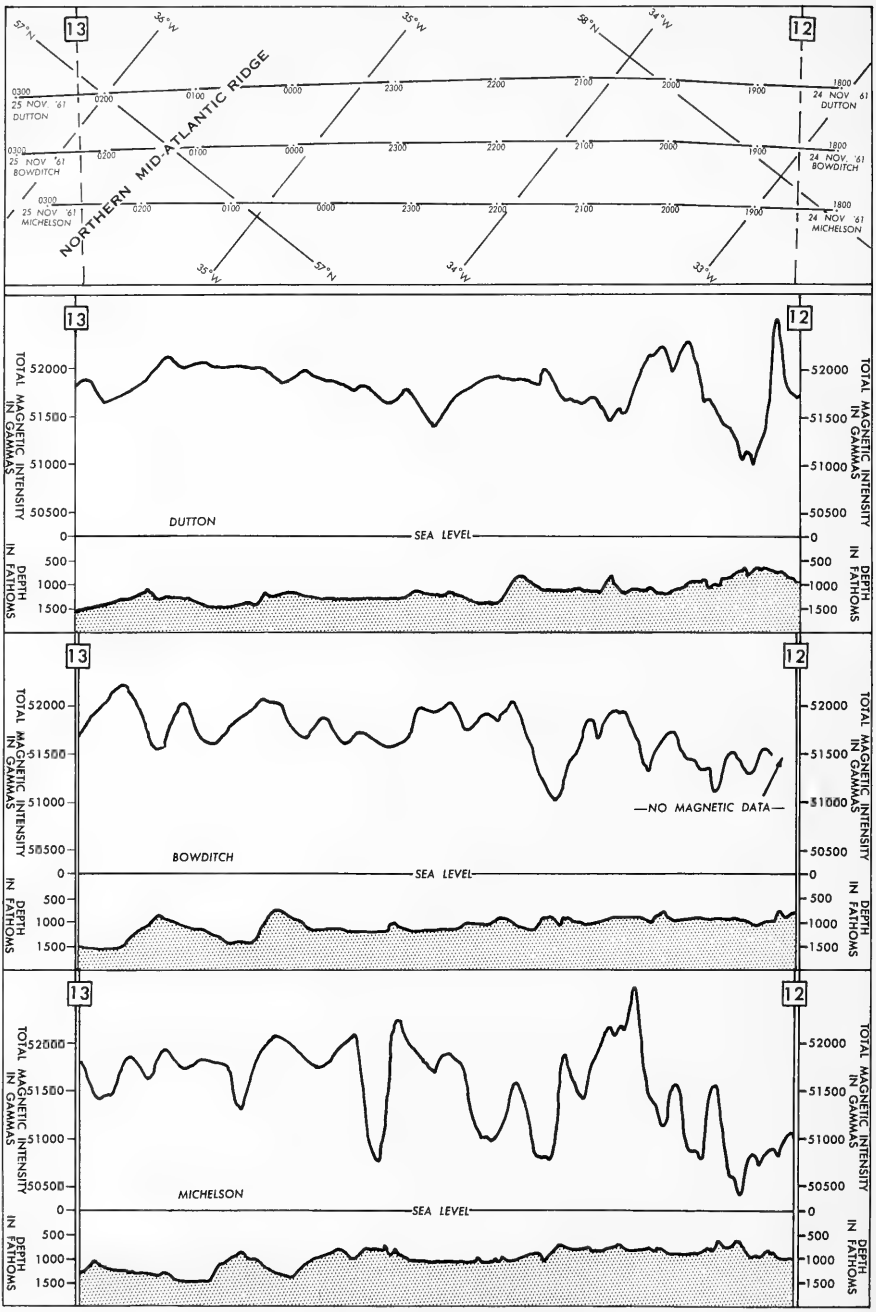

FIGURE 19.— MAGNETIC AND BATHYMETRIC PROFILES 12-13

10 5 0 10 20 30 NAUTICAL MILES

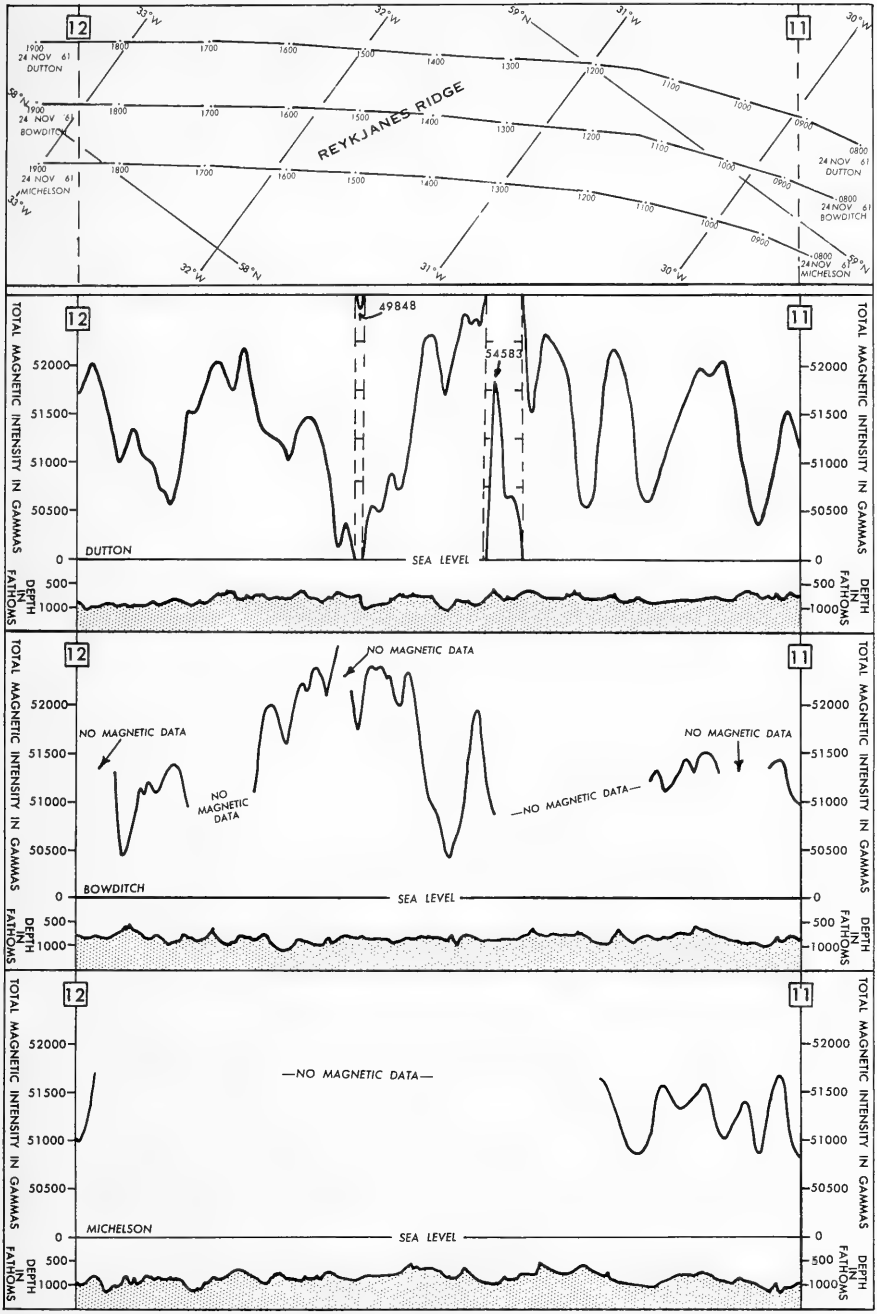

FIGURE 20.— MAGNETIC AND BATHYMETRIC PROFILES 11-12

10 5 0 10 20 30 NAUTICAL MILES

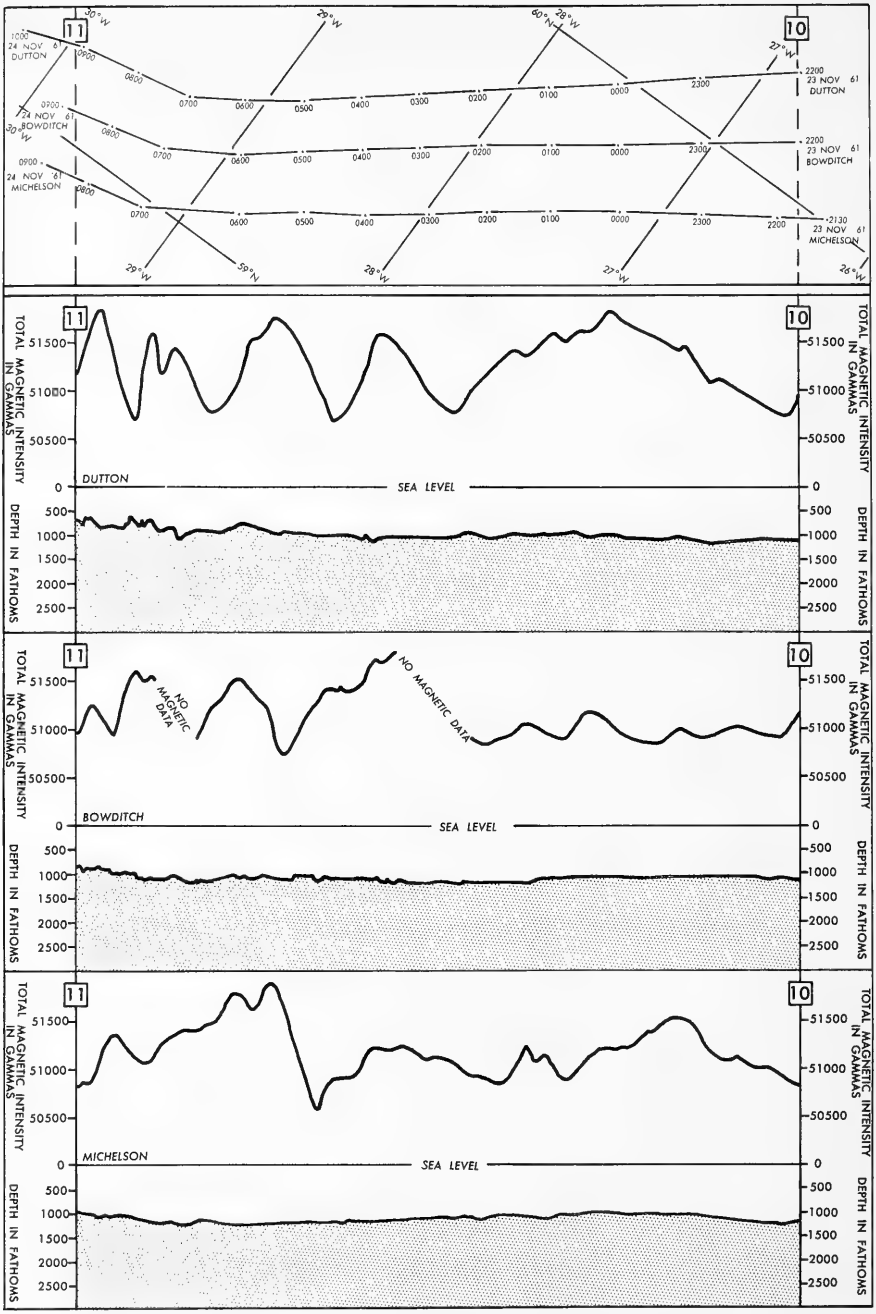

FIGURE 21.— MAGNETIC AND BATHYMETRIC PROFILES 10-11

10 5 0 10 20 30 NAUTICAL MILES

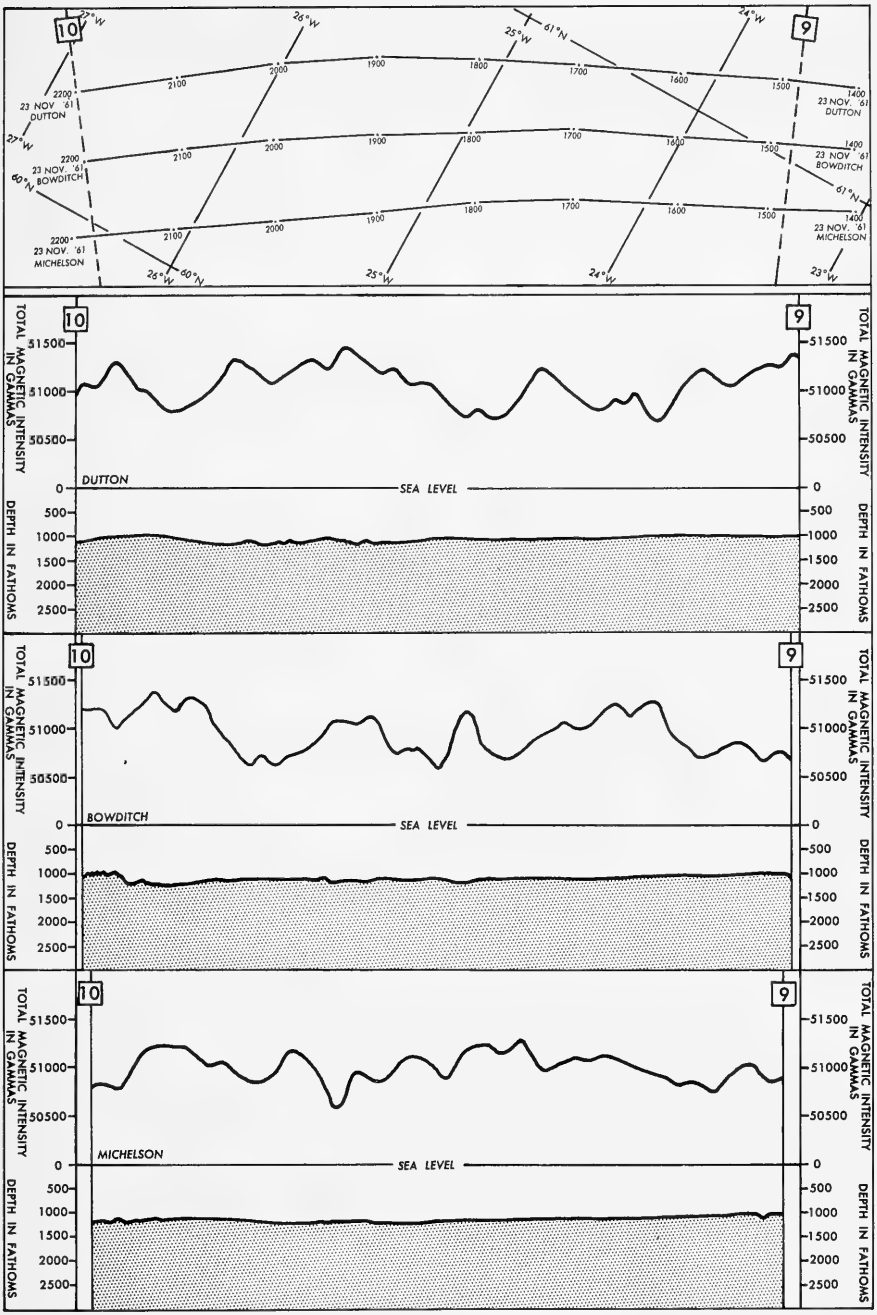

FIGURE 22.— MAGNETIC AND BATHYMETRIC PROFILES 9-10

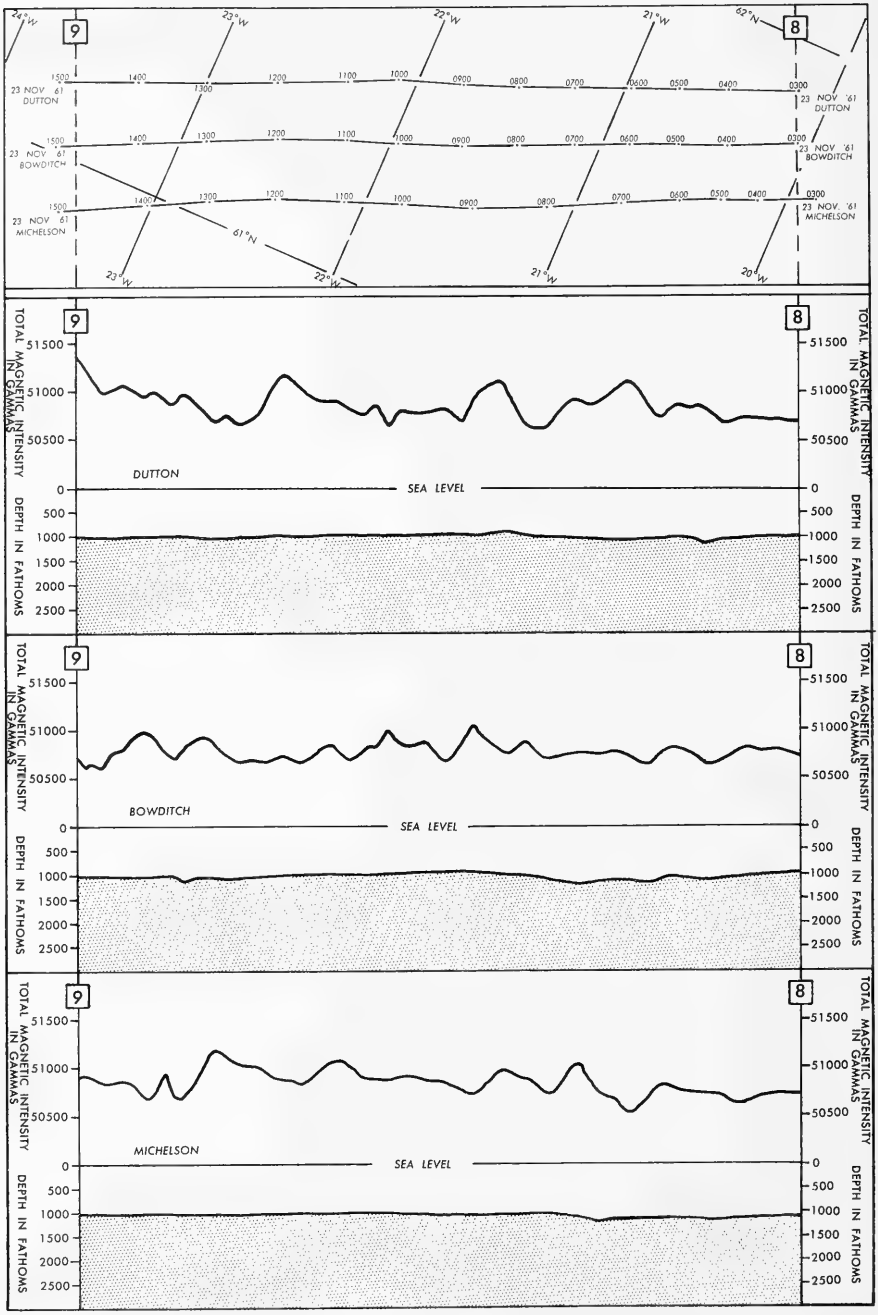

FIGURE 23.— MAGNETIC AND BATHYMETRIC PROFILES 8-9

10 5 0 10 20 30 NAUTICAL MILES

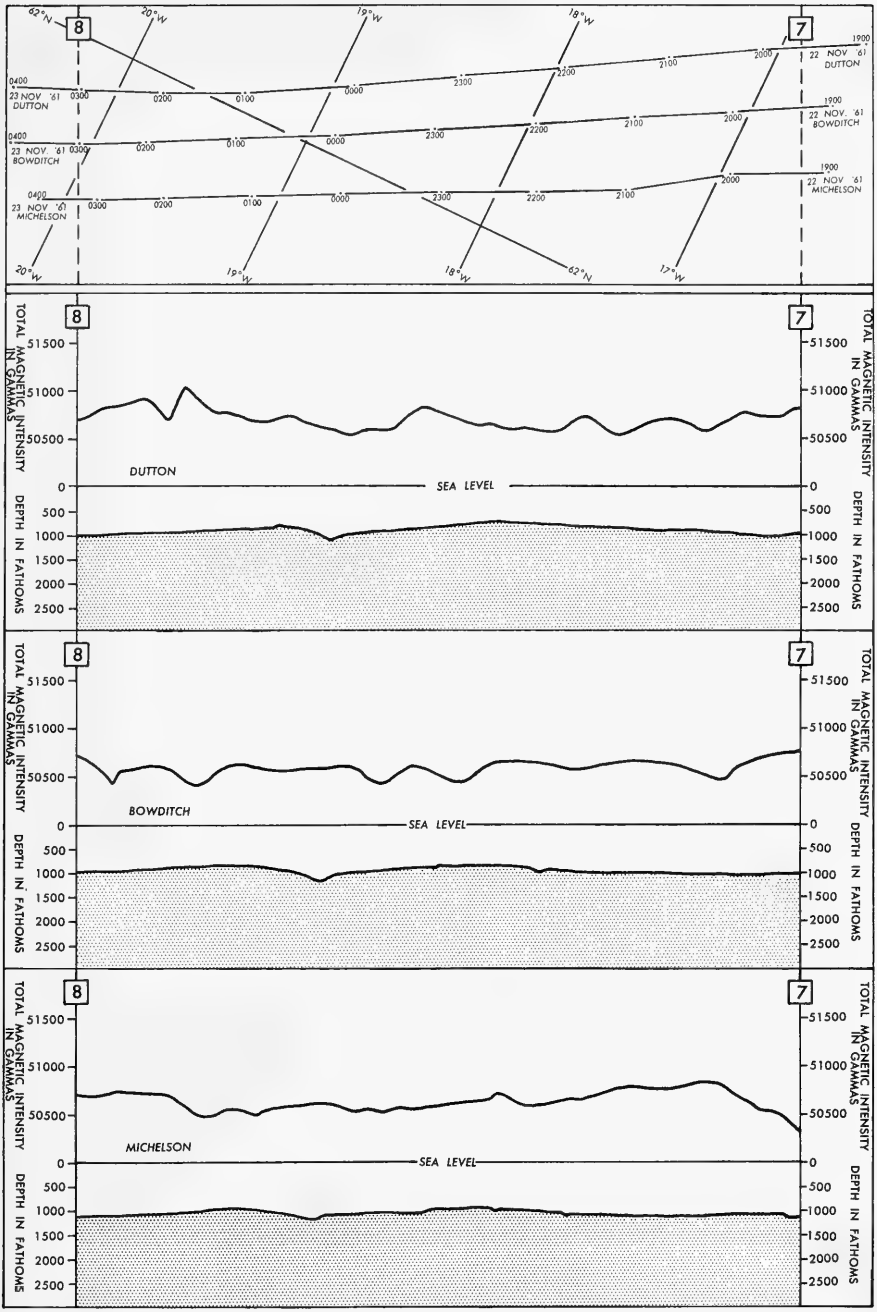

FIGURE 24.— MAGNETIC AND BATHYMETRIC PROFILES · 7-8

10 5 0 10 20 30 NAUTICAL MILES

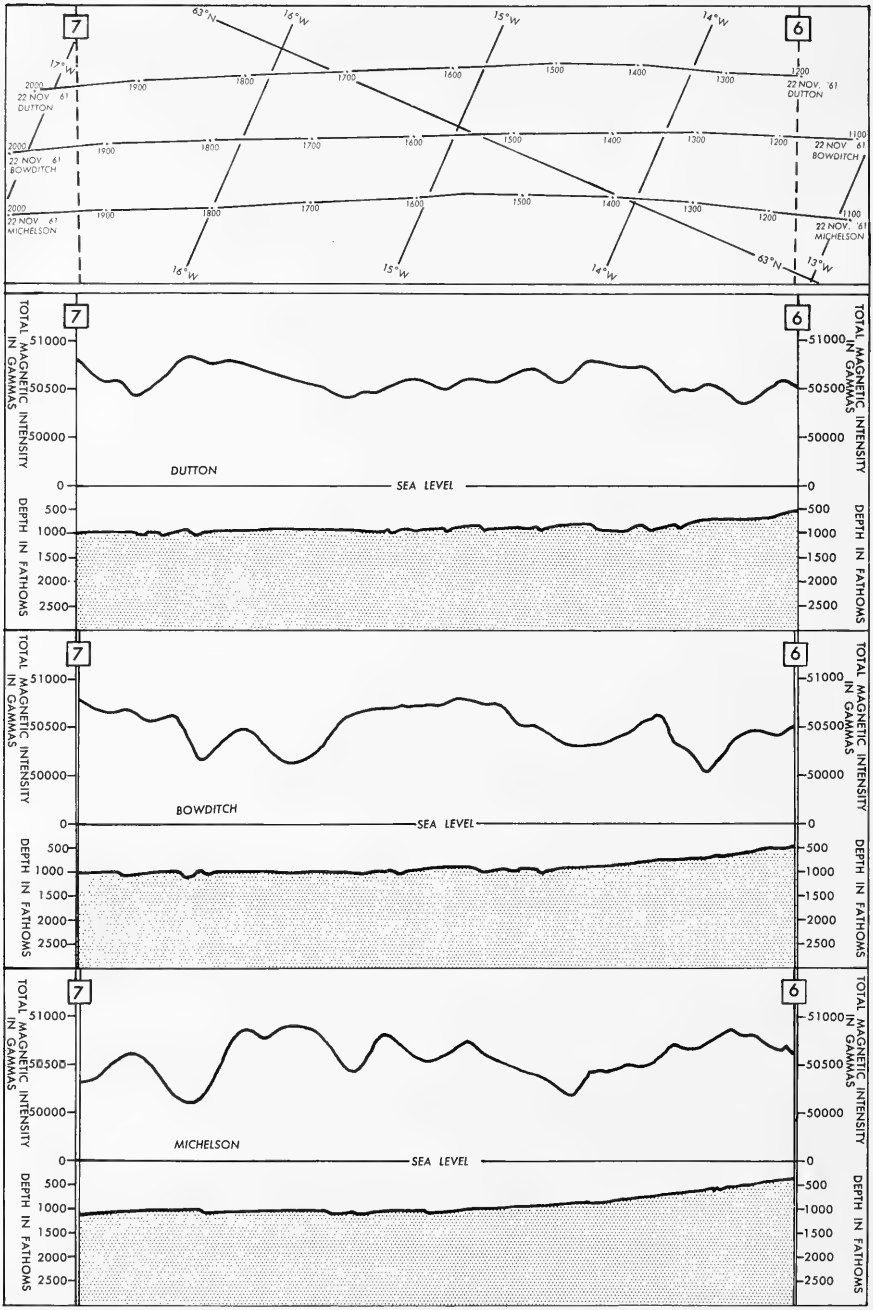

FIGURE 25.— MAGNETIC AND BATHYMETRIC PROFILES 6-7

10 5 0 10 20 30 NAUTICAL MILES

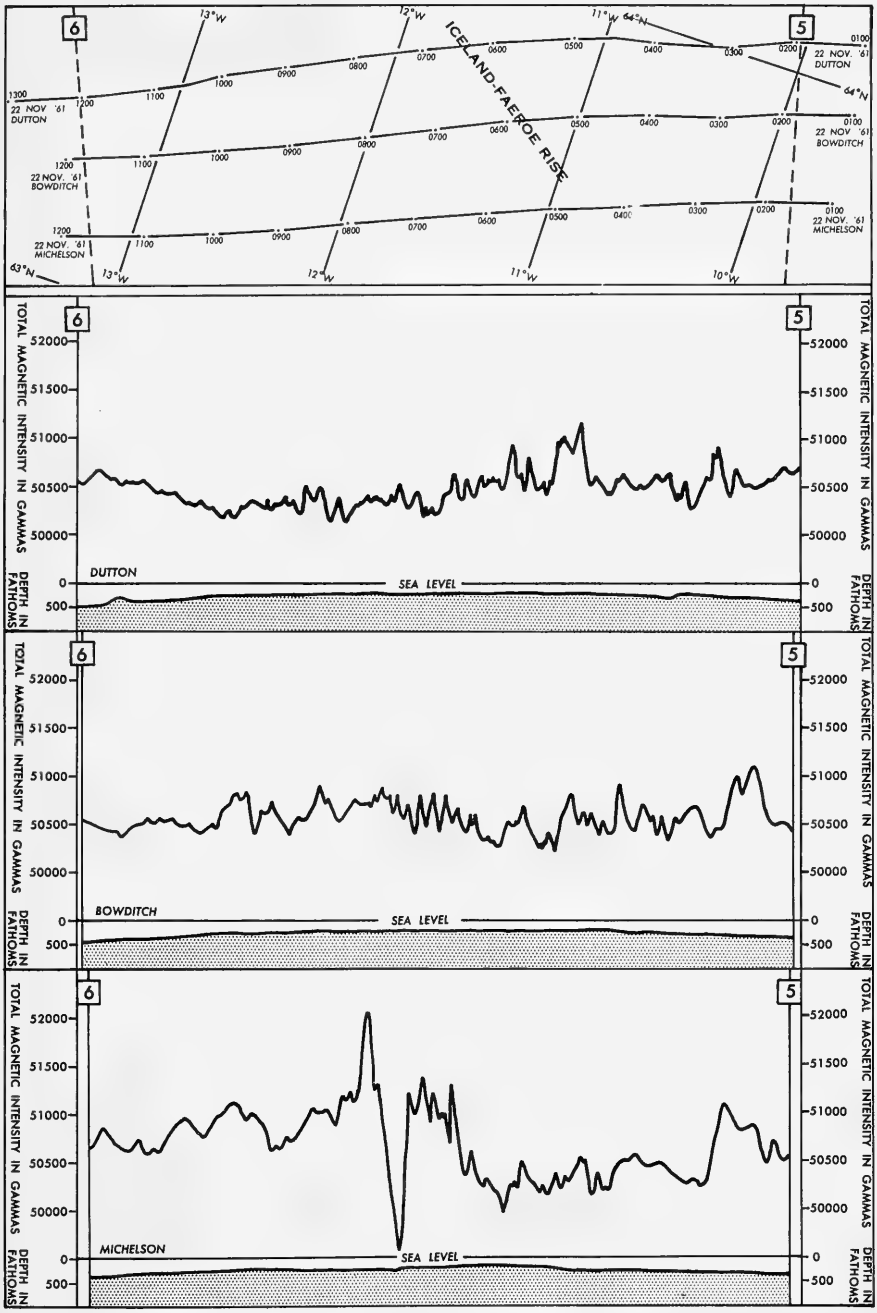

FIGURE 26.—MAGNETIC AND BATHYMETRIC PROFILES 5-6

10 5 0 10 20 30 NAUTICAL MILES

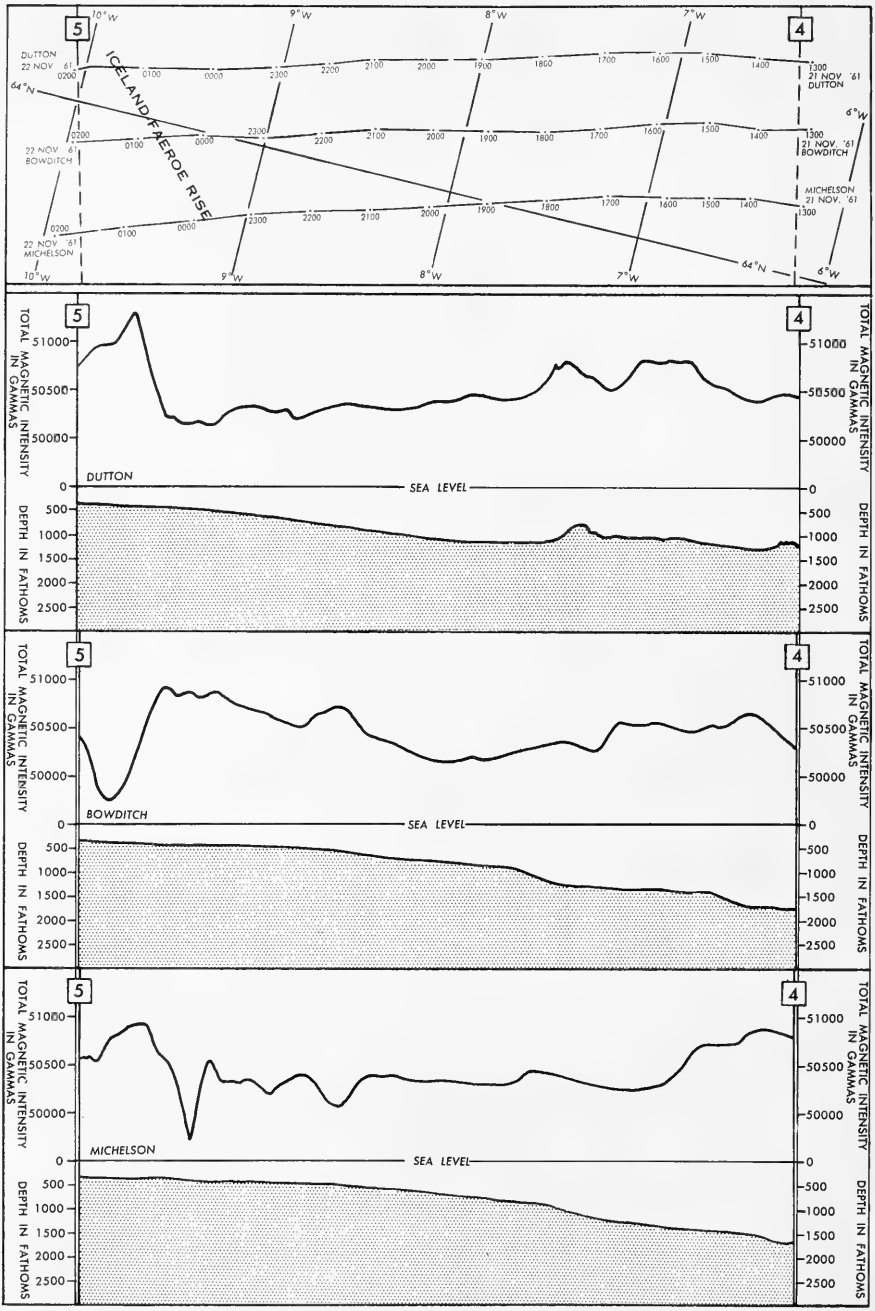

FIGURE 27.— MAGNETIC AND BATHYMETRIC PROFILES 4-5

10 5 0 10 20 30 NAUTICAL MILES

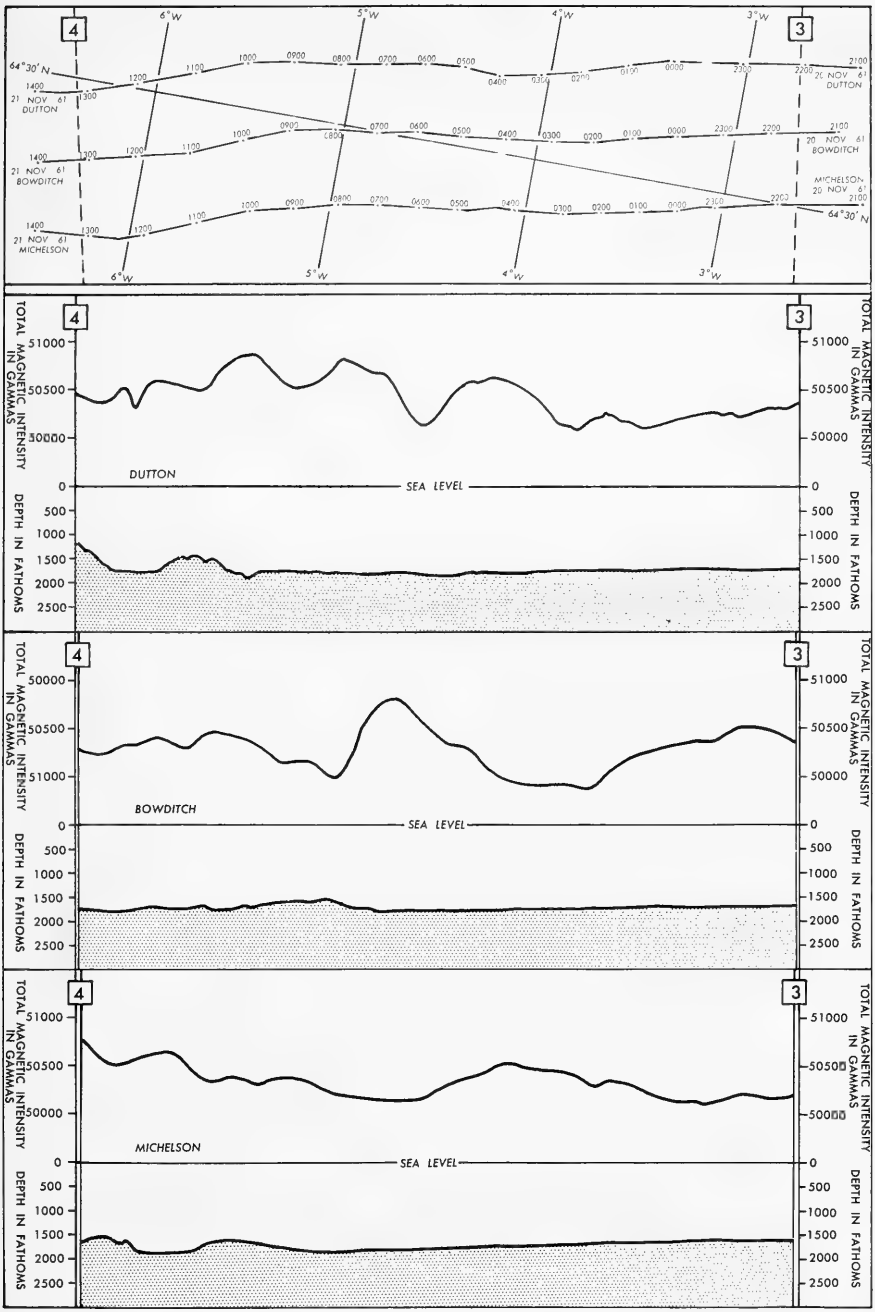

FIGURE 28.—MAGNETIC AND BATHYMETRIC PROFILES 3-4

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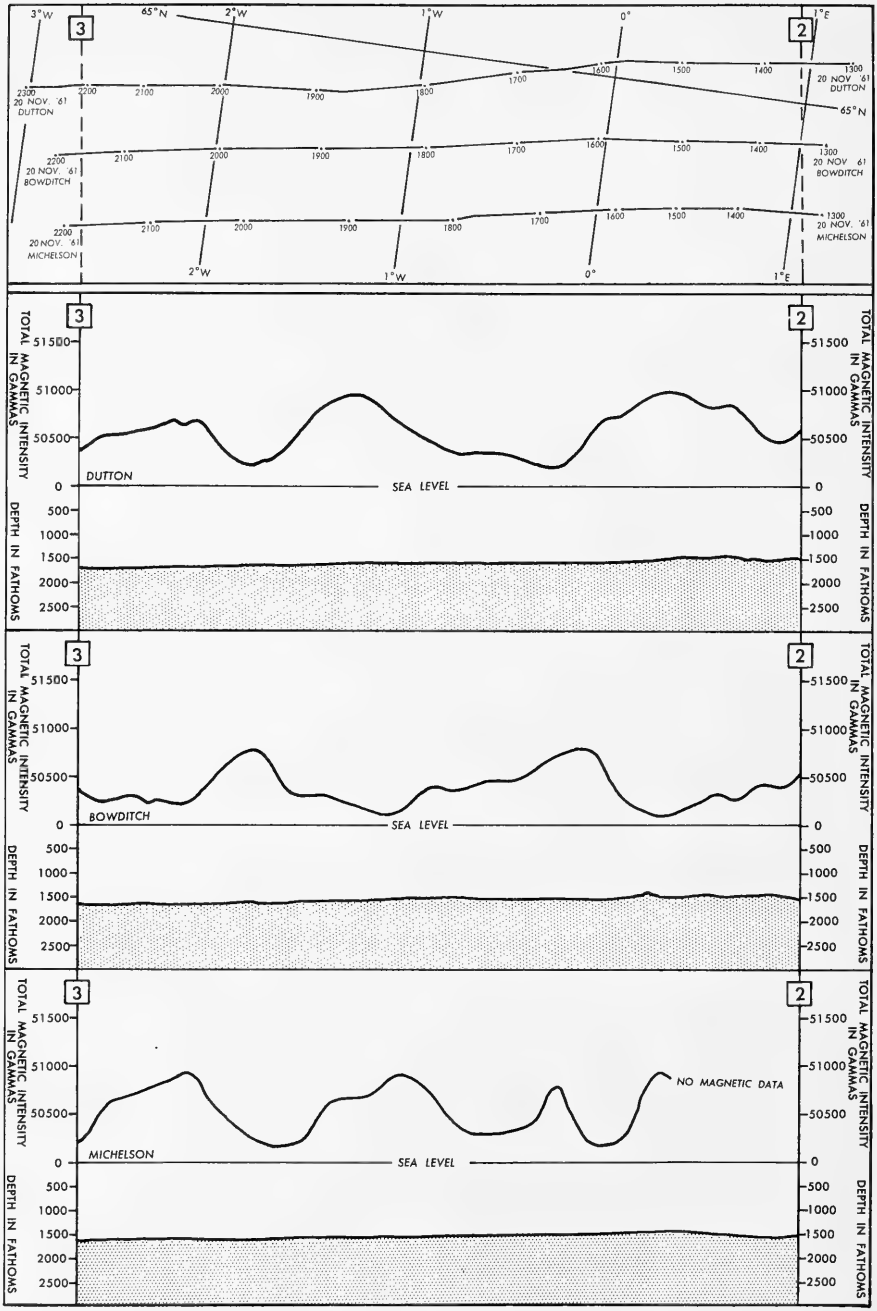


FIGURE 29.— MAGNETIC AND BATHYMETRIC PROFILES 2-3

10 5 0 10 20 30 NAUTICAL MILES

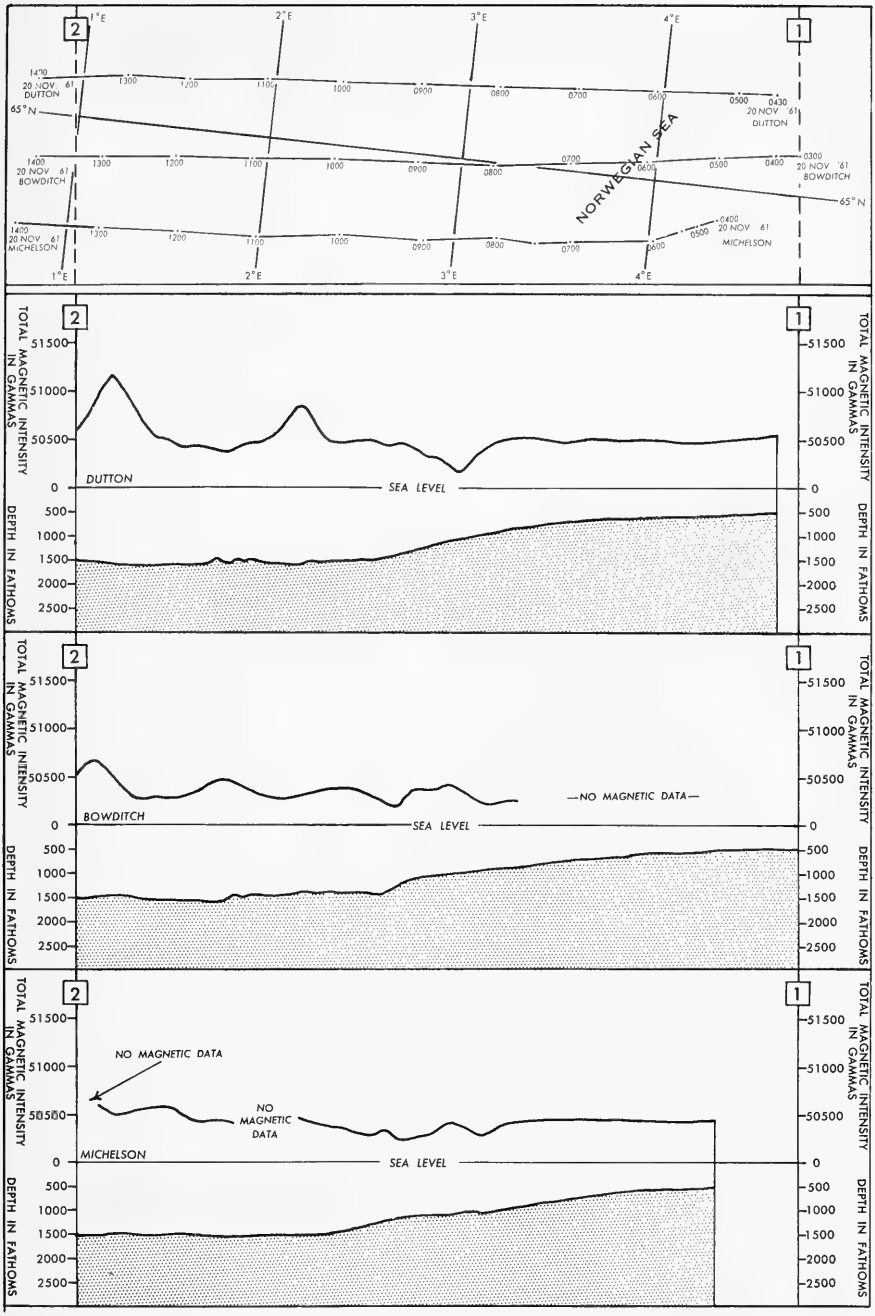


FIGURE 30.— MAGNETIC AND BATHYMETRIC PROFILES 1-2

10 5 0 10 20 30 NAUTICAL MILES

PART II: NEW YORK - NORWEGIAN SEA

(FIGS. 31-60)

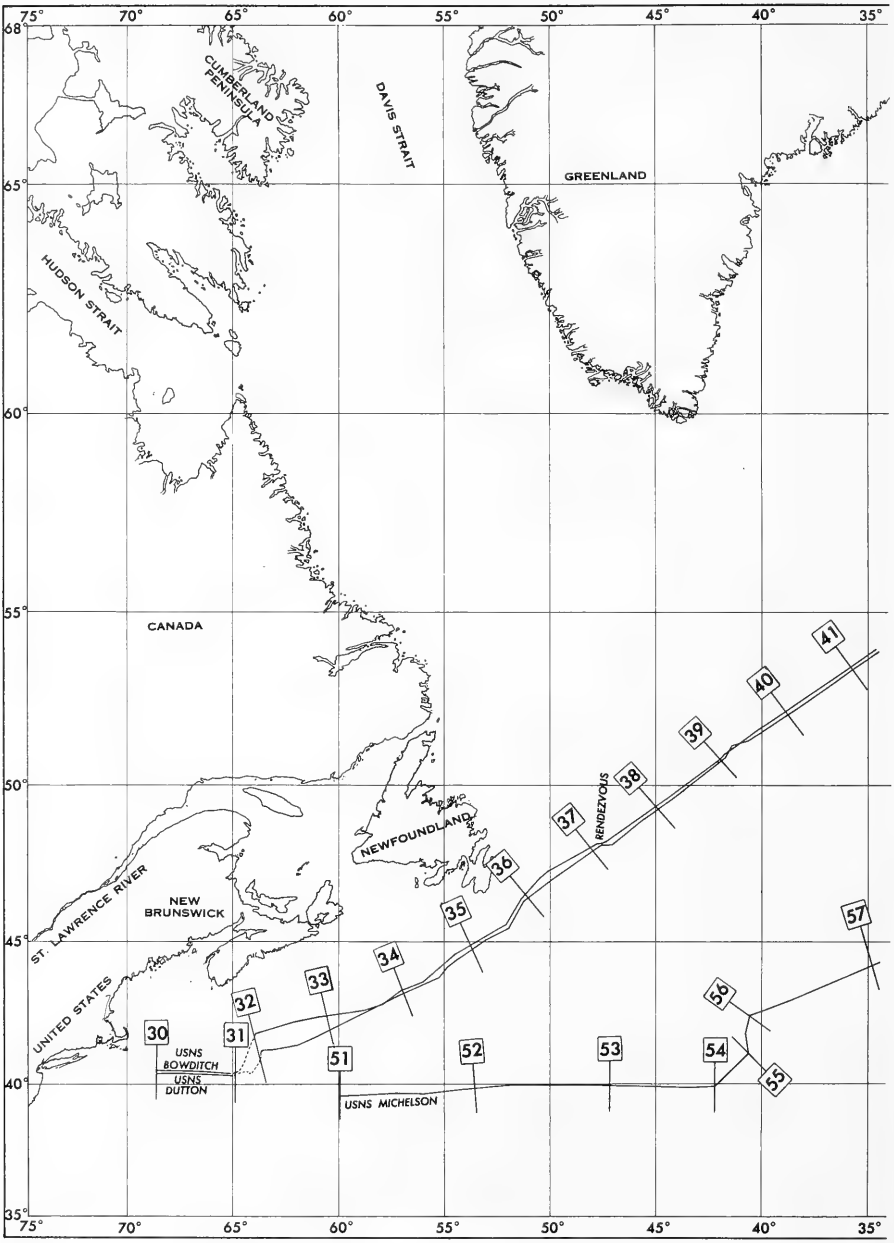
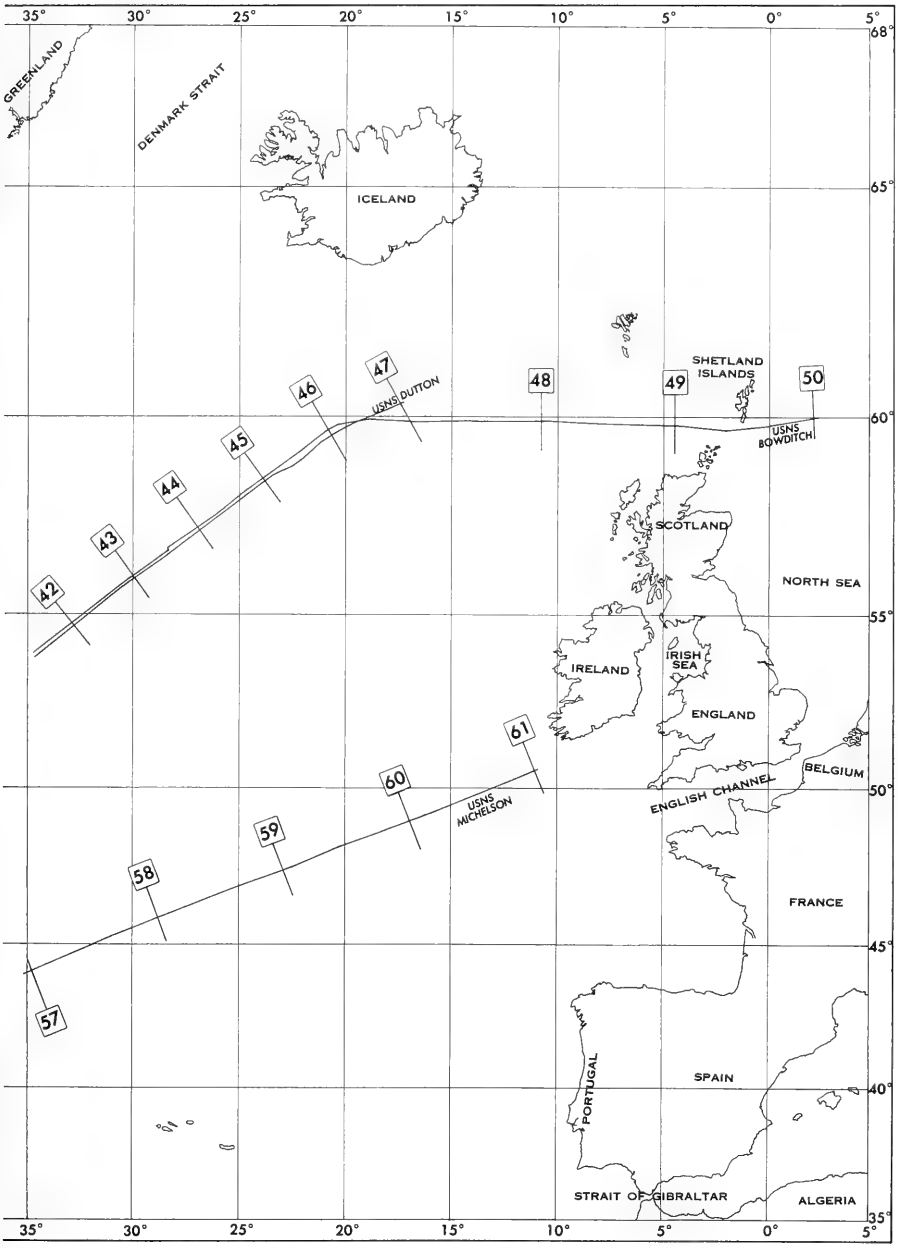


FIGURE 31.— PROFILE INDEX NEW YORK—NORWEGIAN SEA


35°
30°
25°
20°
15°
10°
5°
0°
5°
68°
65°
60°
55°
50°
45°
40°
35°
GREENLAND
DENMARK STRAIT
ICELAND
SHETLAND ISLANDS
USNS DUTTON
USNS BOWDITCH
USNS MICHELSON
42
43
44
45
46
47
48
49
50
57
58
59
60
61
SCOTLAND
NORTH SEA
IRELAND
IRISH SEA
ENGLAND
BELGIUM
ENGLISH CHANNEL
FRANCE
SPAIN
PORTUGAL
STRAIT OF GIBRALTAR
ALGERIA

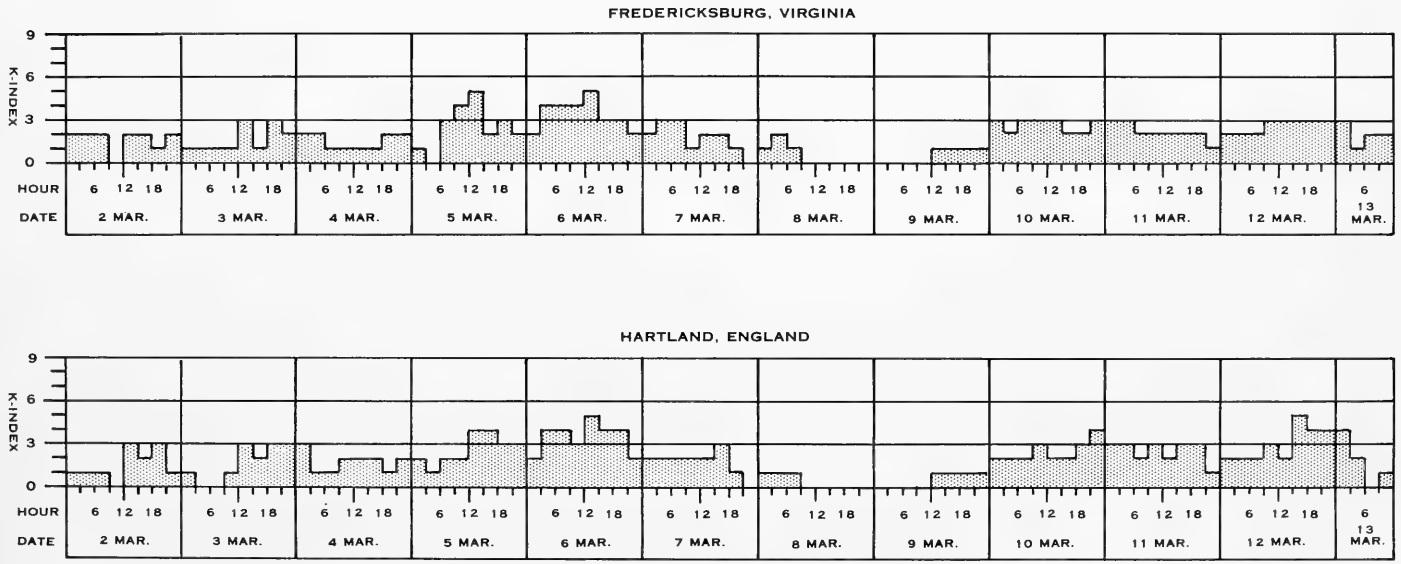


FIGURE 32.—K-INDICES OF GEOMAGNETIC ACTIVITY

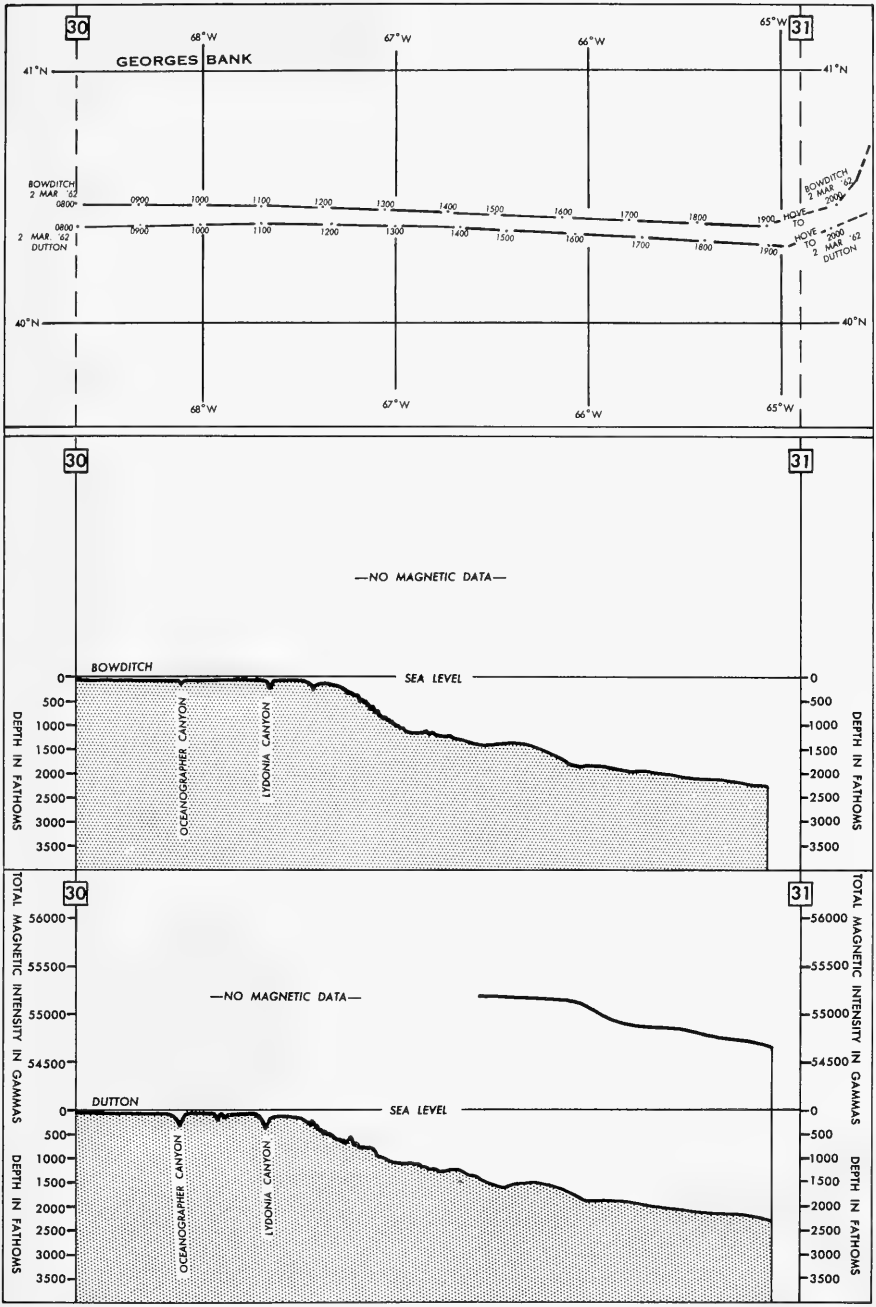


FIGURE 33.— MAGNETIC AND BATHYMETRIC PROFILES 30-31

10 5 0 10 20 30 NAUTICAL MILES

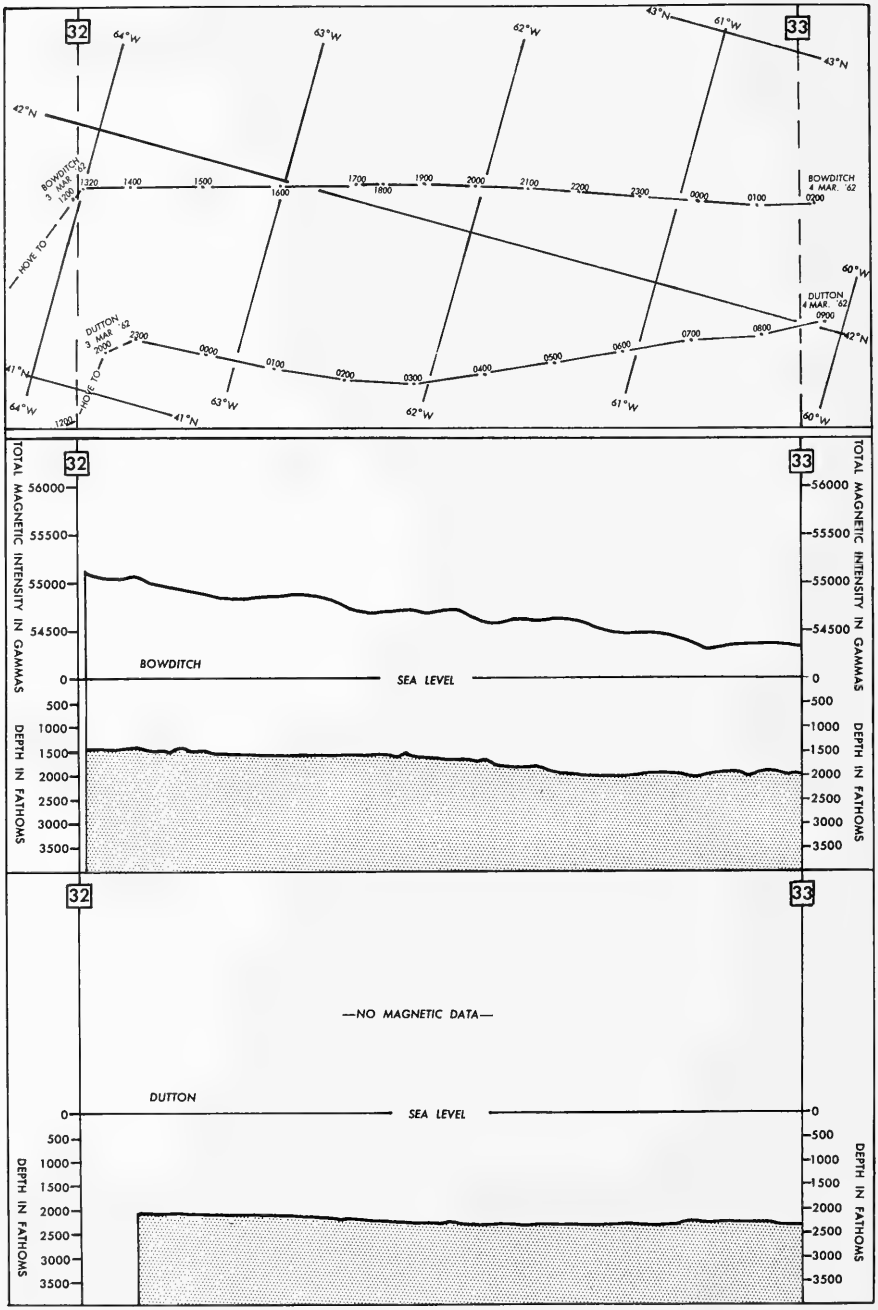


FIGURE 34.— MAGNETIC AND BATHYMETRIC PROFILES 32-33

10 5 0 10 20 30
NAUTICAL MILES

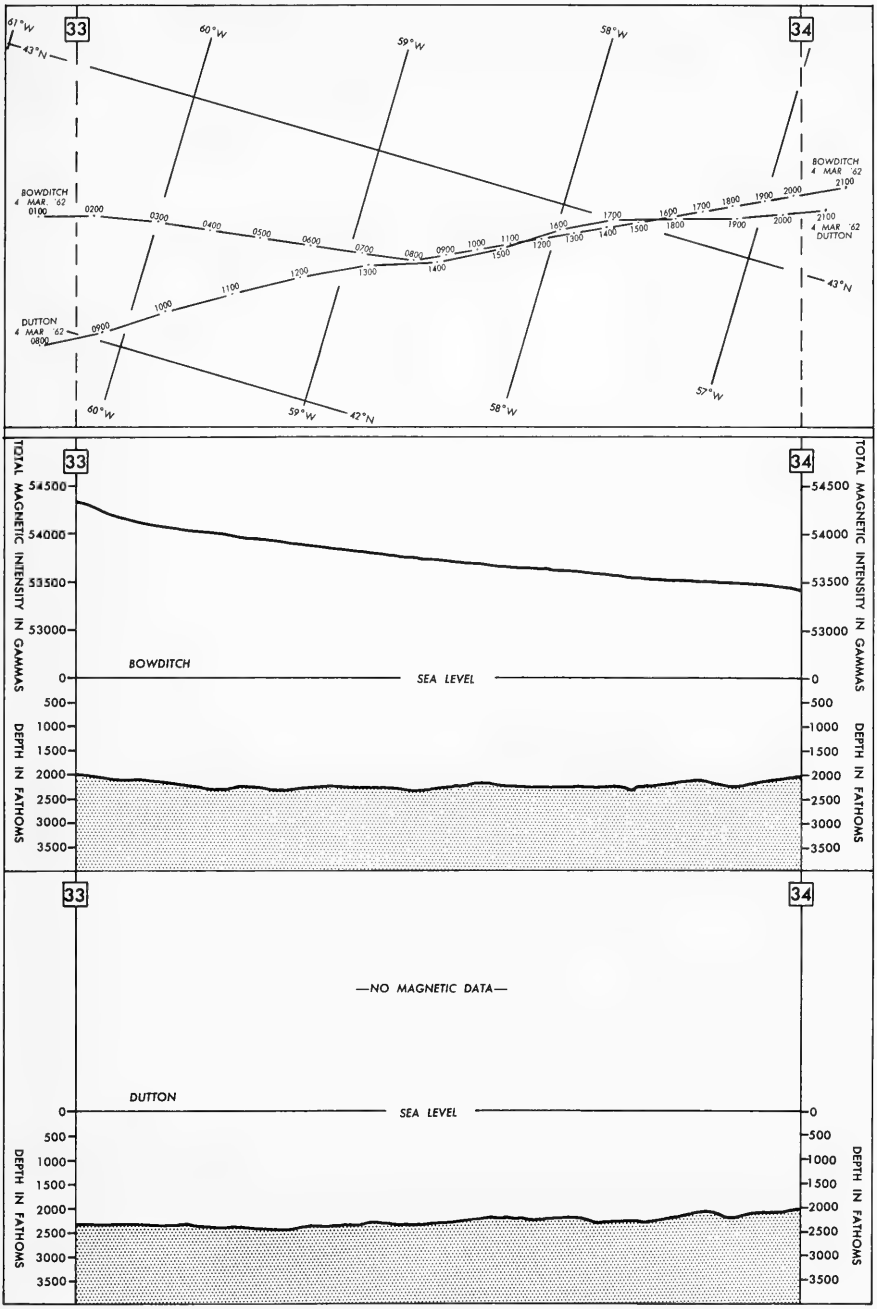


FIGURE 35.— MAGNETIC AND BATHYMETRIC PROFILES 33-34

10 5 0 10 20 30 NAUTICAL MILES

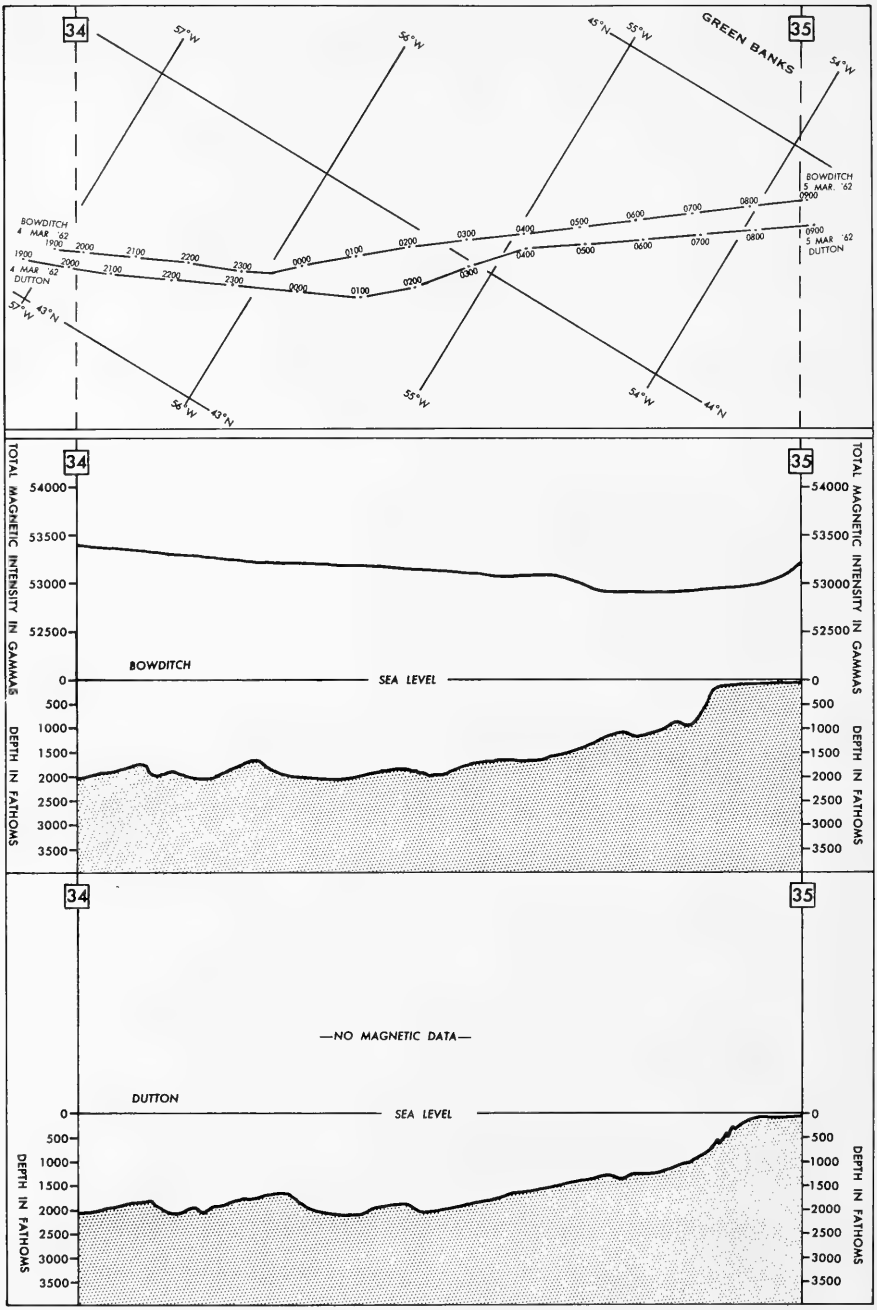


FIGURE 36.— MAGNETIC AND BATHYMETRIC PROFILES 34-35

10 5 0 10 20 30 NAUTICAL MILES

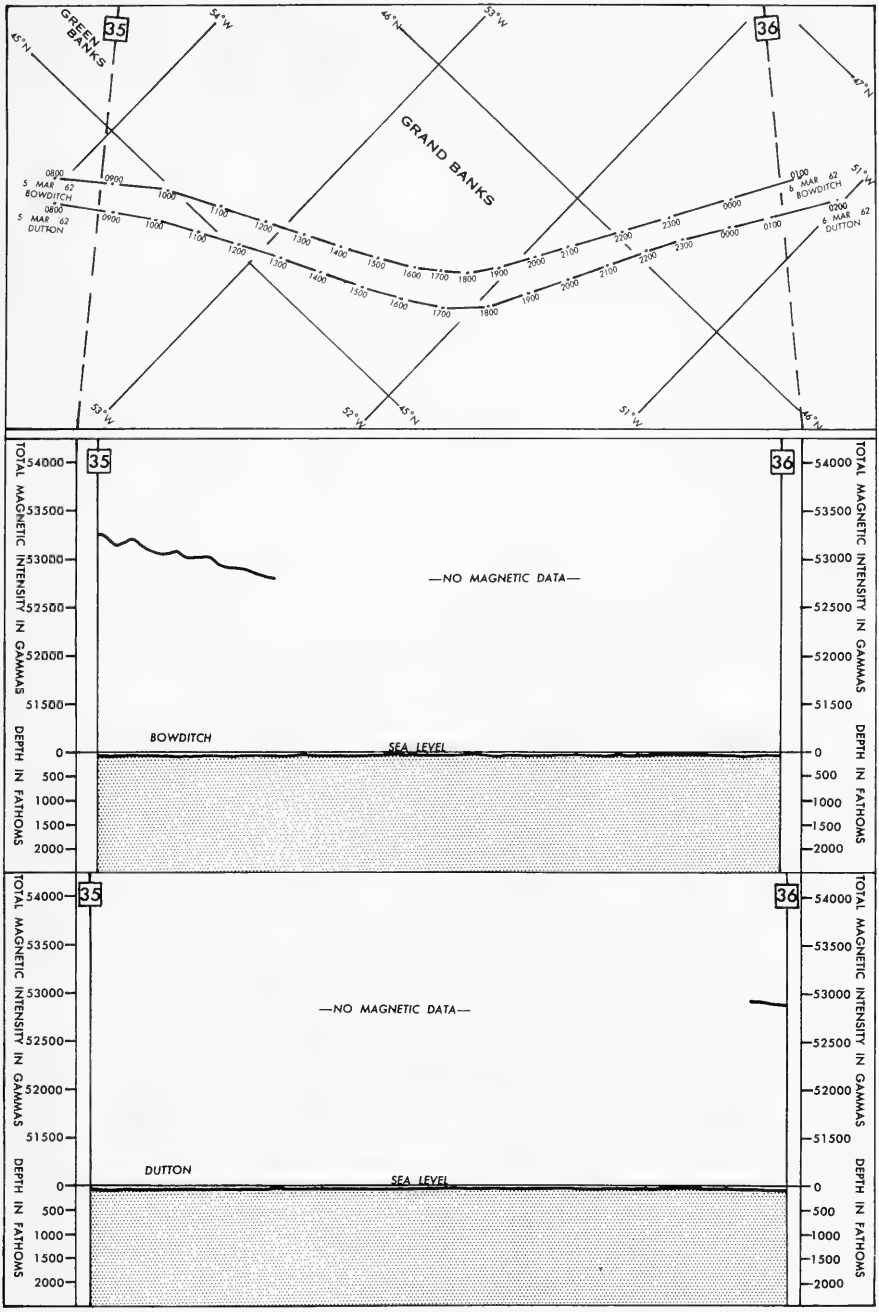


FIGURE 37.— MAGNETIC AND BATHYMETRIC PROFILES 35-36

10 5 0 10 20 30 NAUTICAL MILES

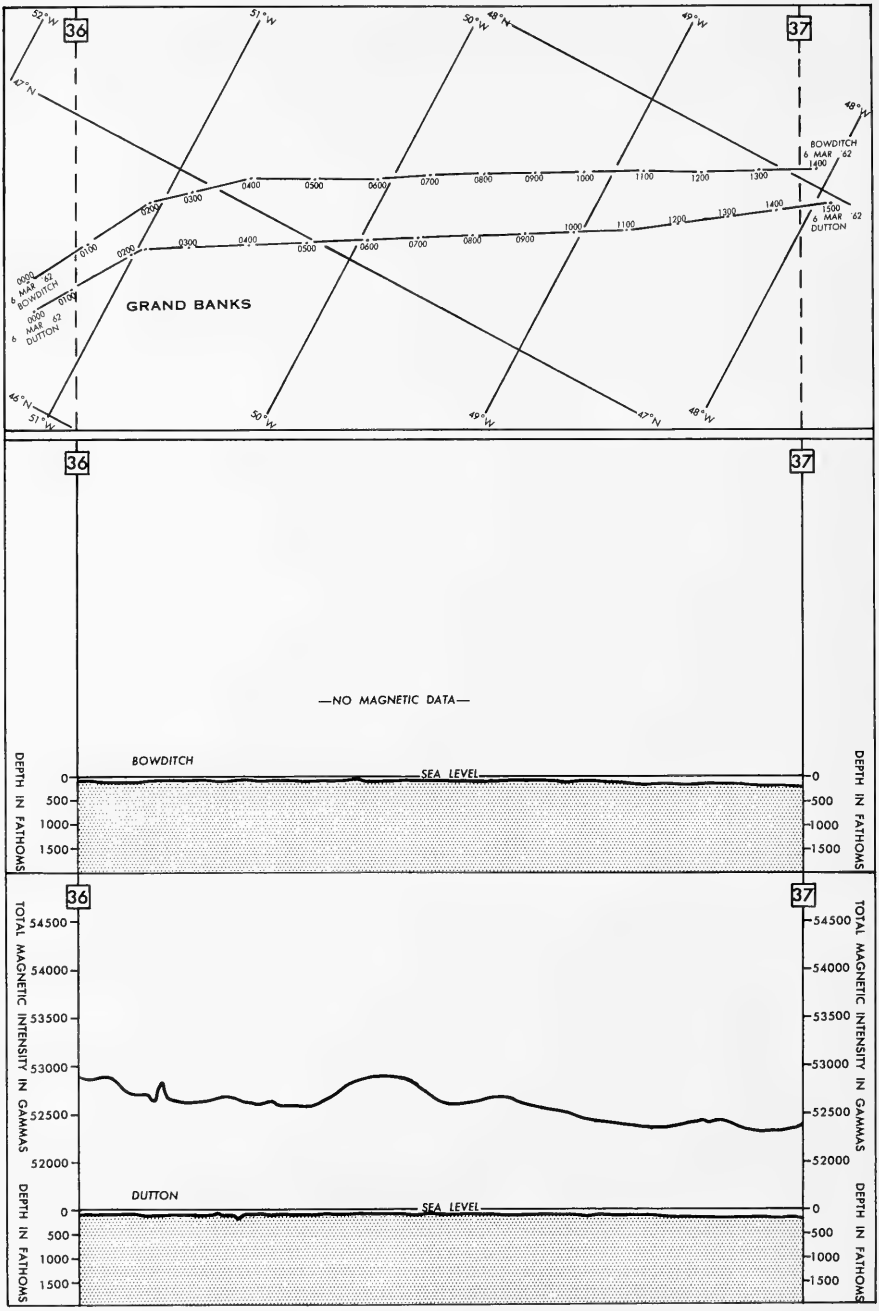


FIGURE 38.— MAGNETIC AND BATHYMETRIC PROFILES 36-37

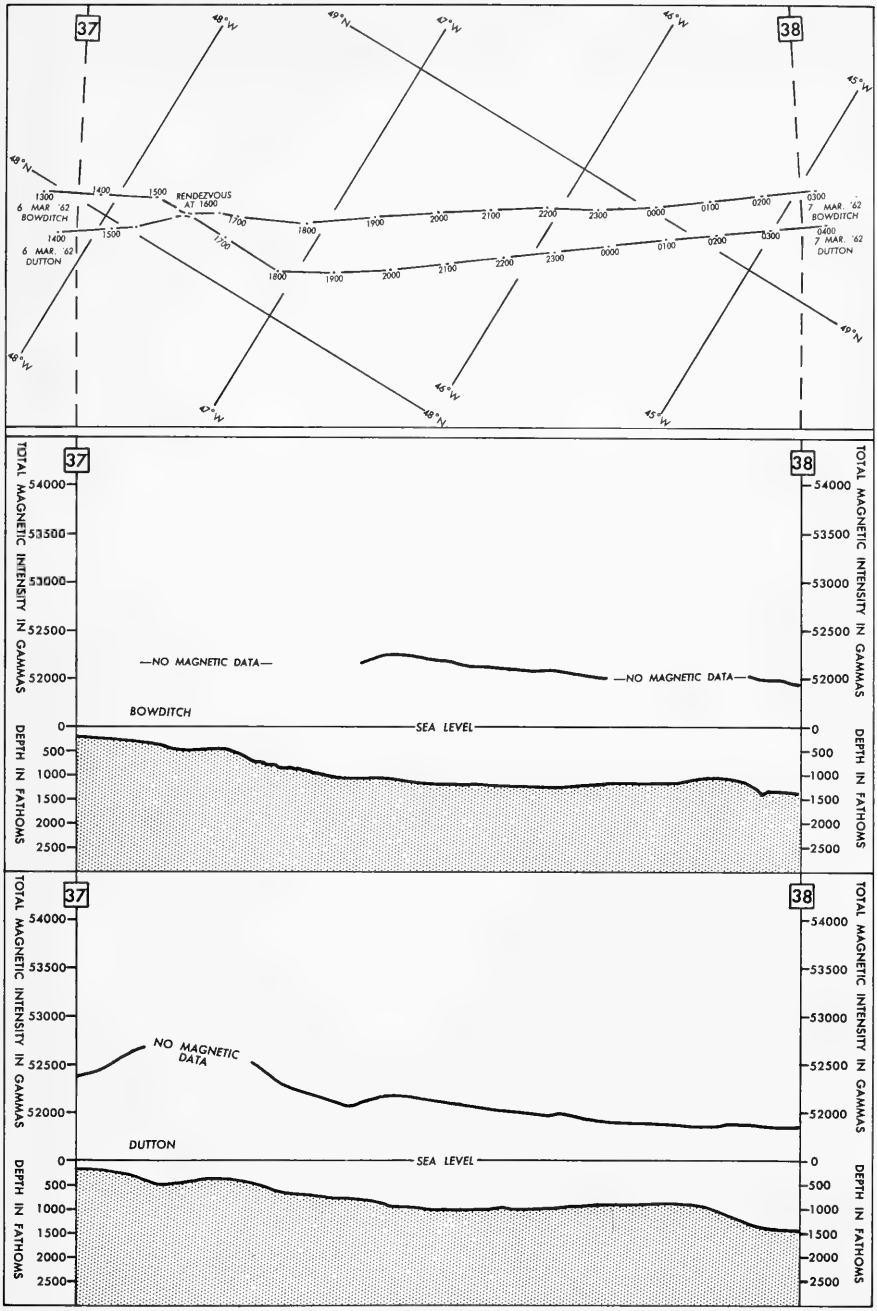


FIGURE 39.— MAGNETIC AND BATHYMETRIC PROFILES 37-38

10 5 0 10 20 30 NAUTICAL MILES

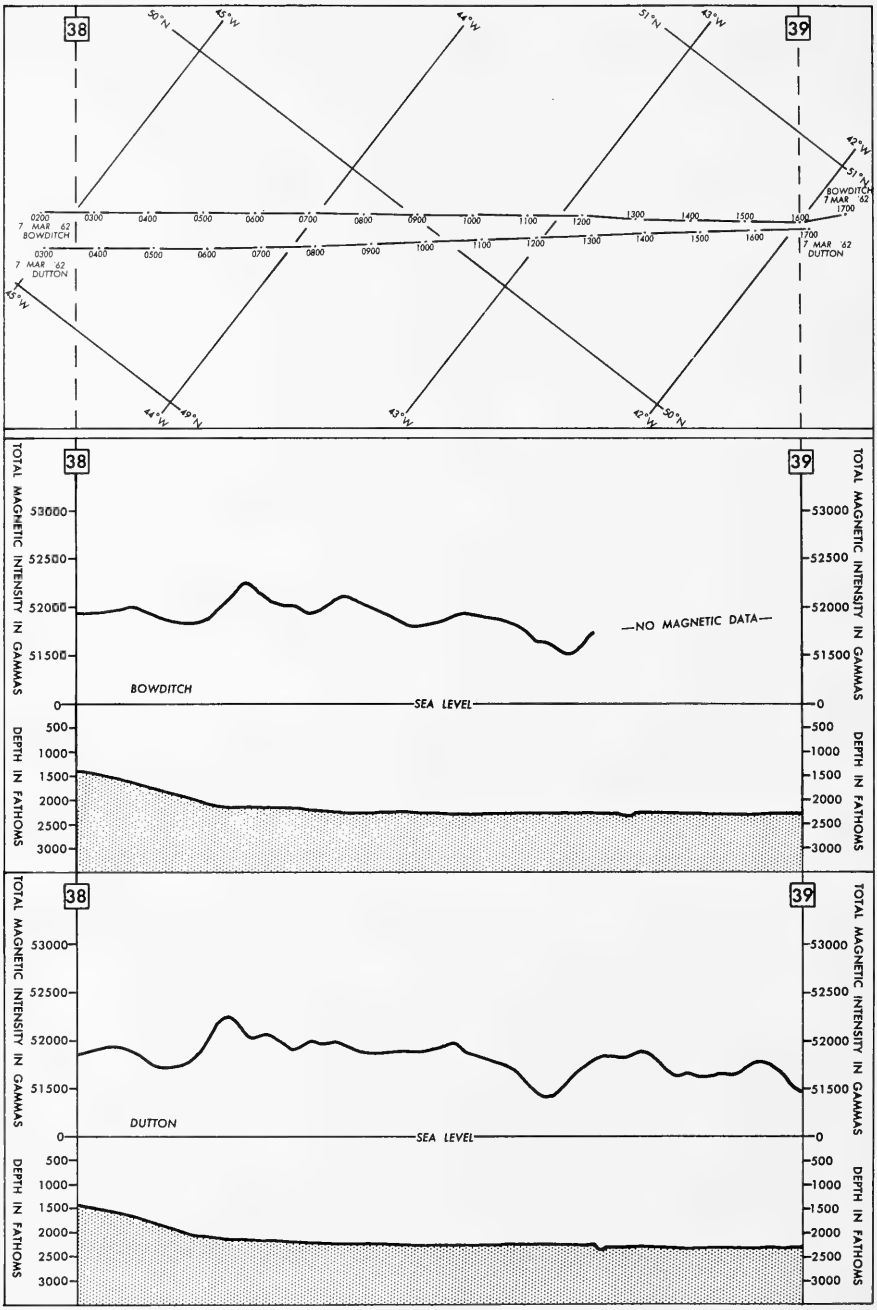


FIGURE 40.— MAGNETIC AND BATHYMETRIC PROFILES 38-39

10 5 0 10 20 30
NAUTICAL MILES

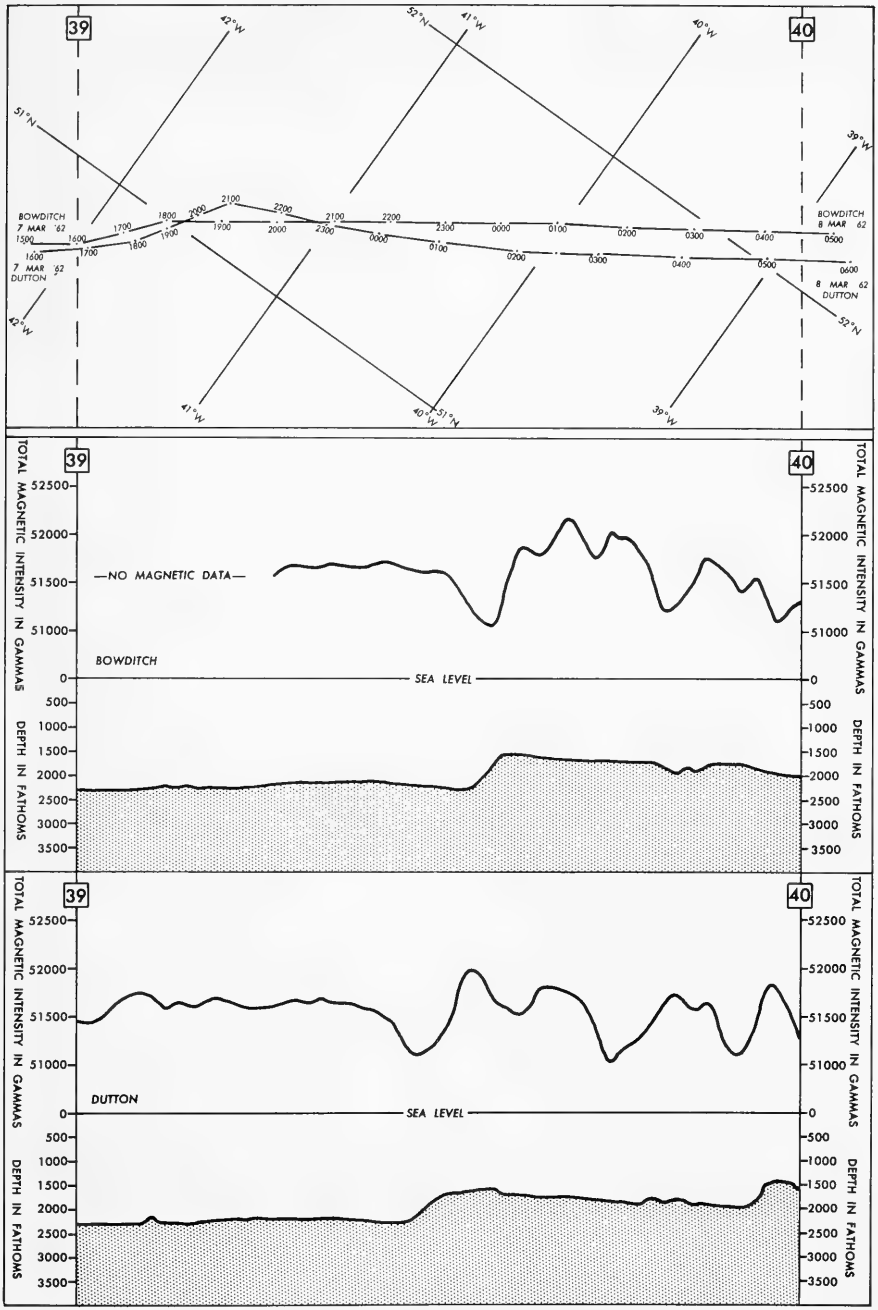


FIGURE 41.— MAGNETIC AND BATHYMETRIC PROFILES 39-40

10 5 0 10 20 30
NAUTICAL MILES

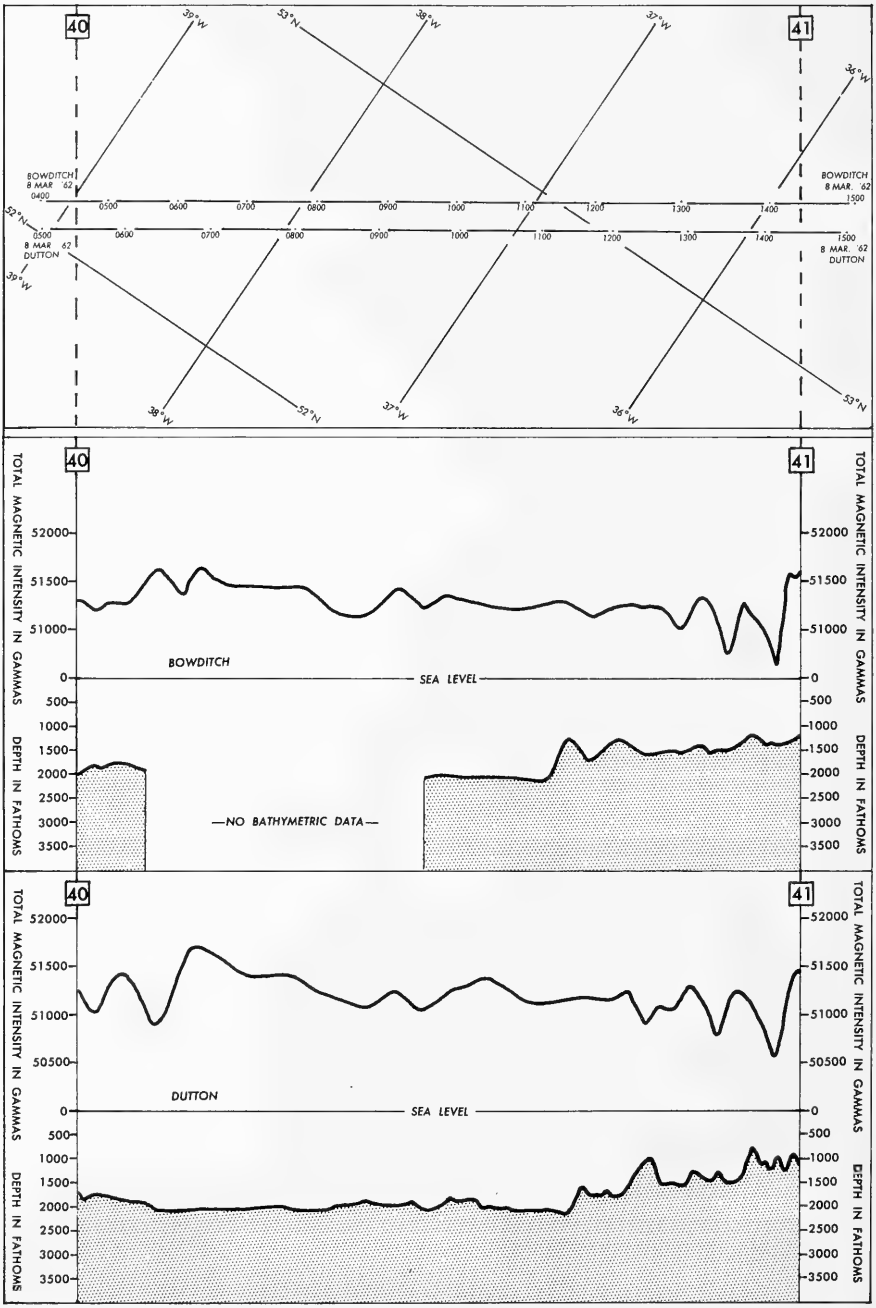


FIGURE 42.— MAGNETIC AND BATHYMETRIC PROFILES 40-41

10 5 0 10 20 30 NAUTICAL MILES

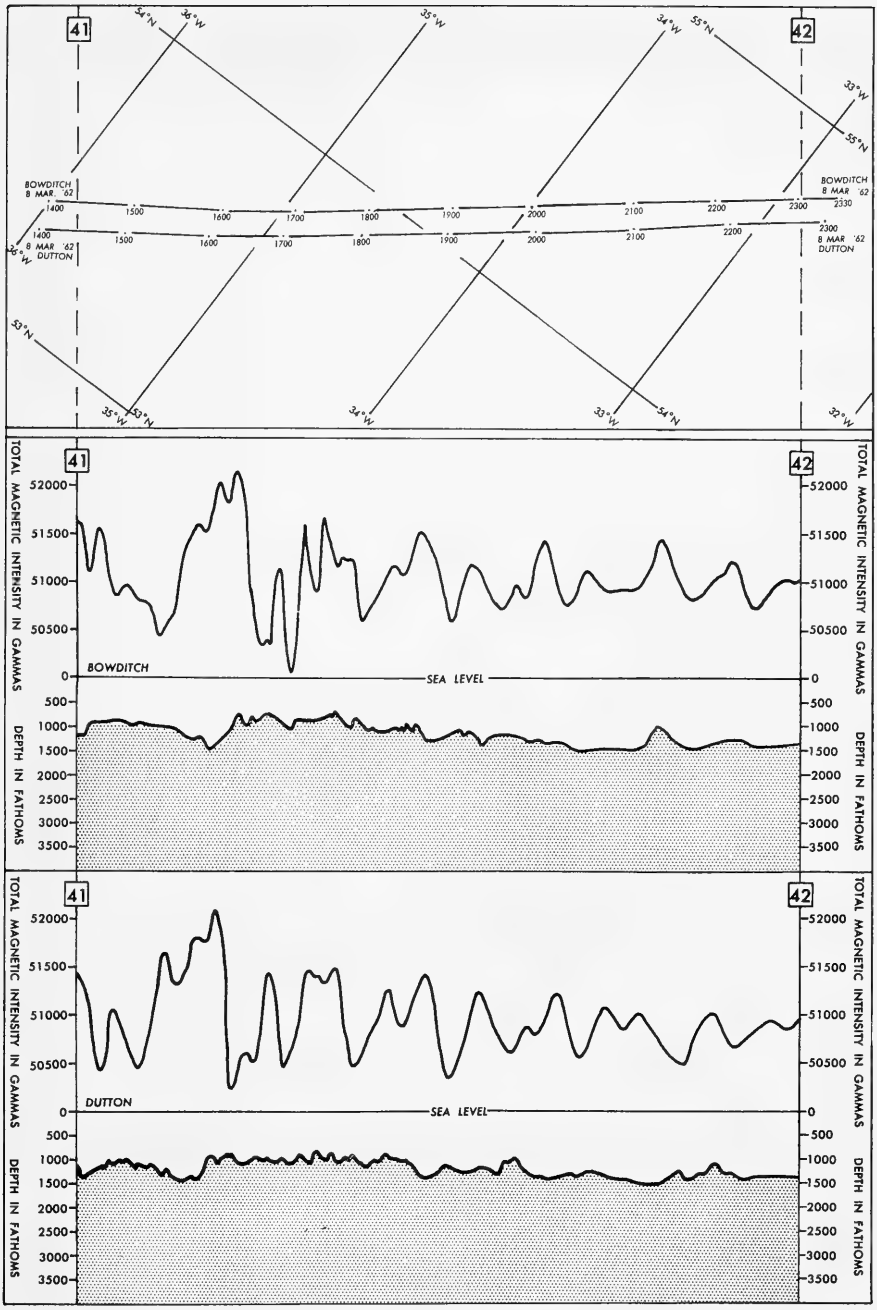


FIGURE 43.— MAGNETIC AND BATHYMETRIC PROFILES 41-42

10 5 0 10 20 30 NAUTICAL MILES

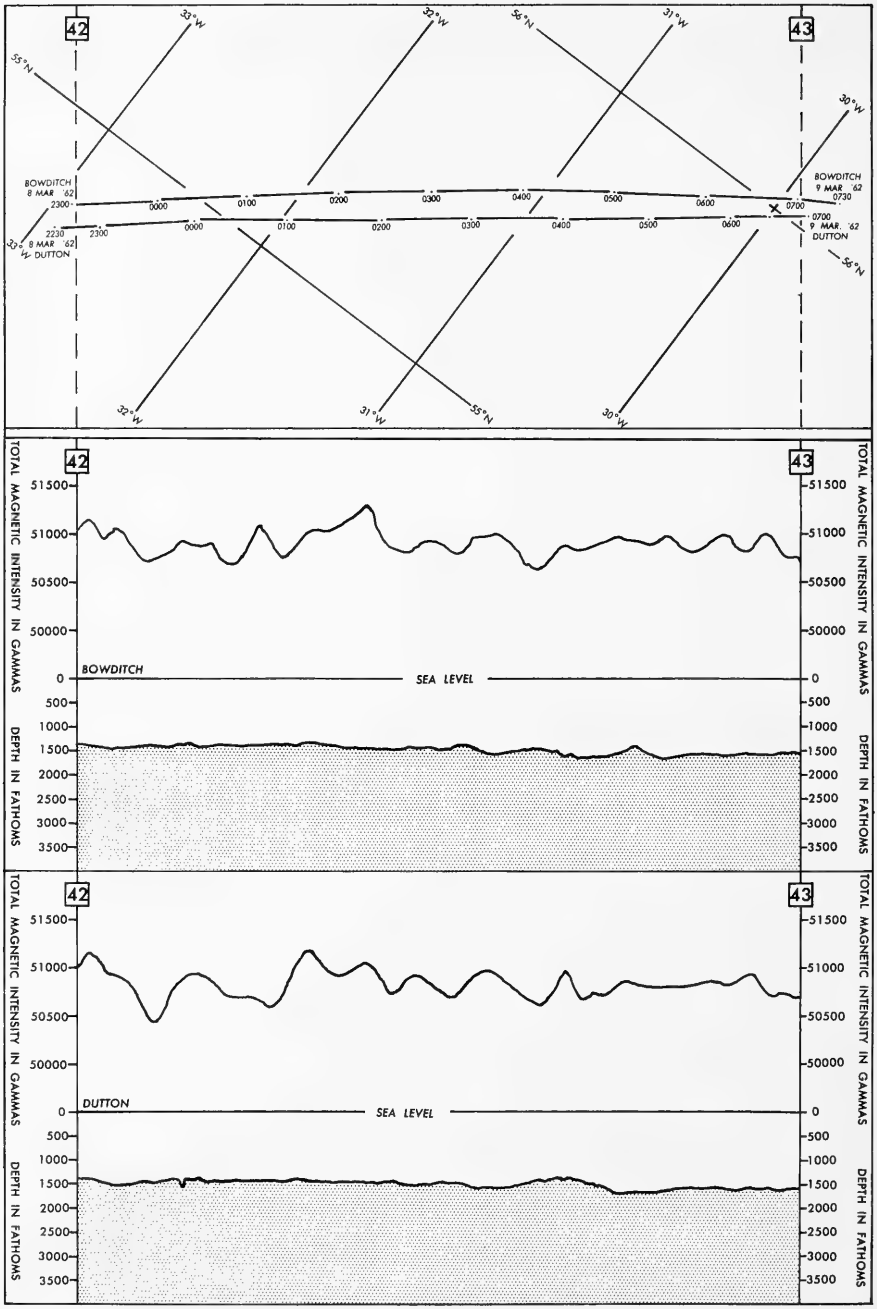


FIGURE 44.— MAGNETIC AND BATHYMETRIC PROFILES 42-43

10 5 0 10 20 30 NAUTICAL MILES

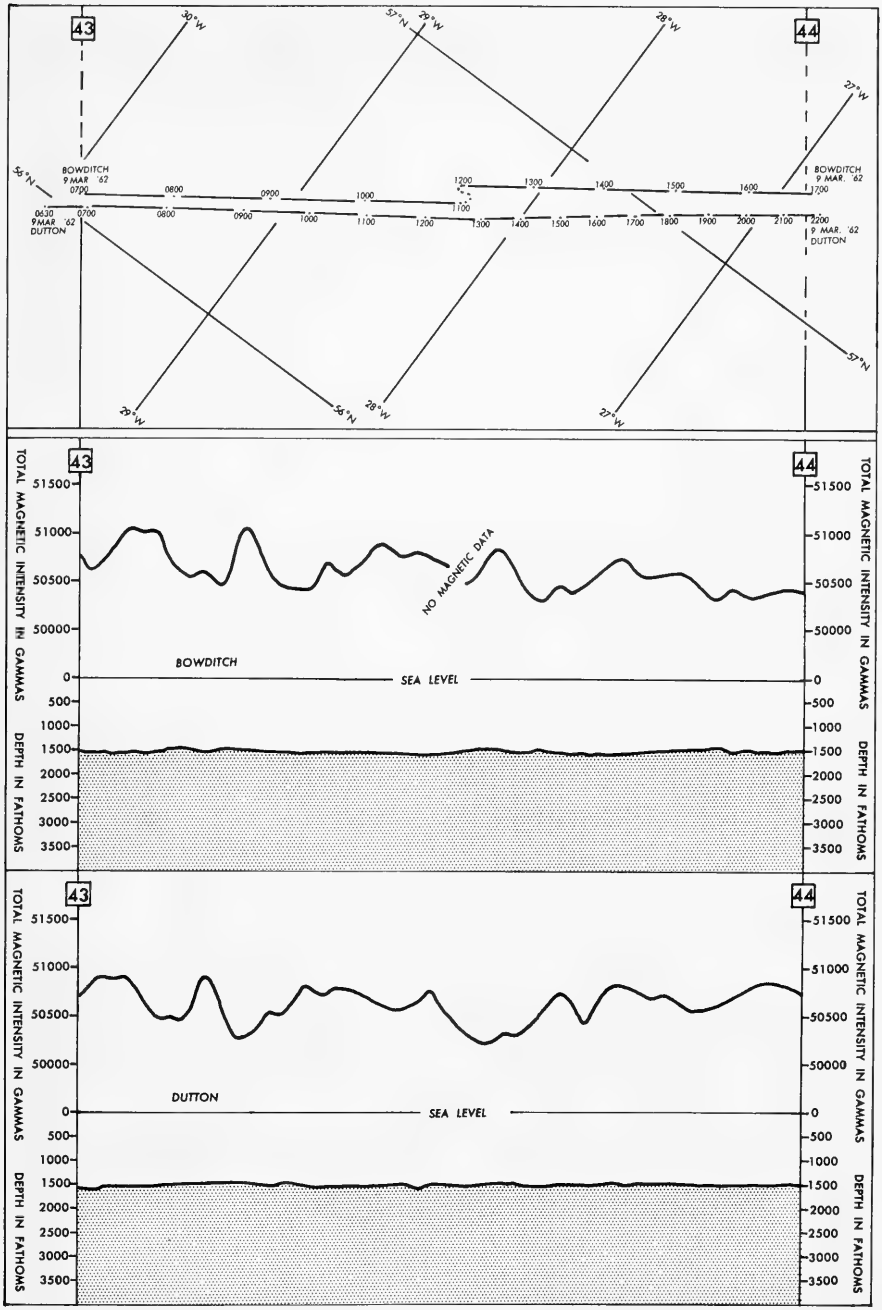


FIGURE 45.— MAGNETIC AND BATHYMETRIC PROFILES 43-44

10 5 0 10 20 30 NAUTICAL MILES

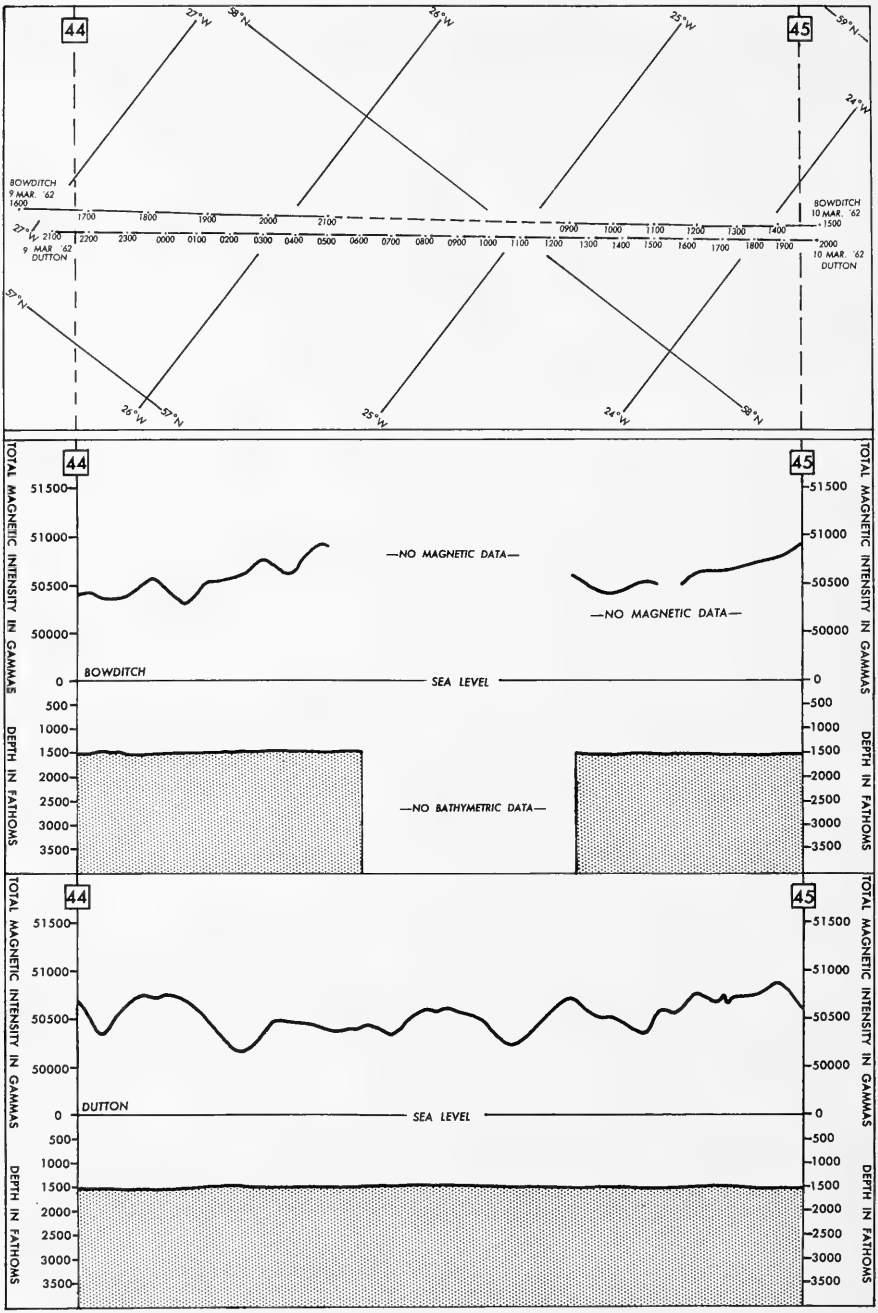


FIGURE 46.—MAGNETIC AND BATHYMETRIC PROFILES 44-45

10 5 0 10 20 30 NAUTICAL MILES

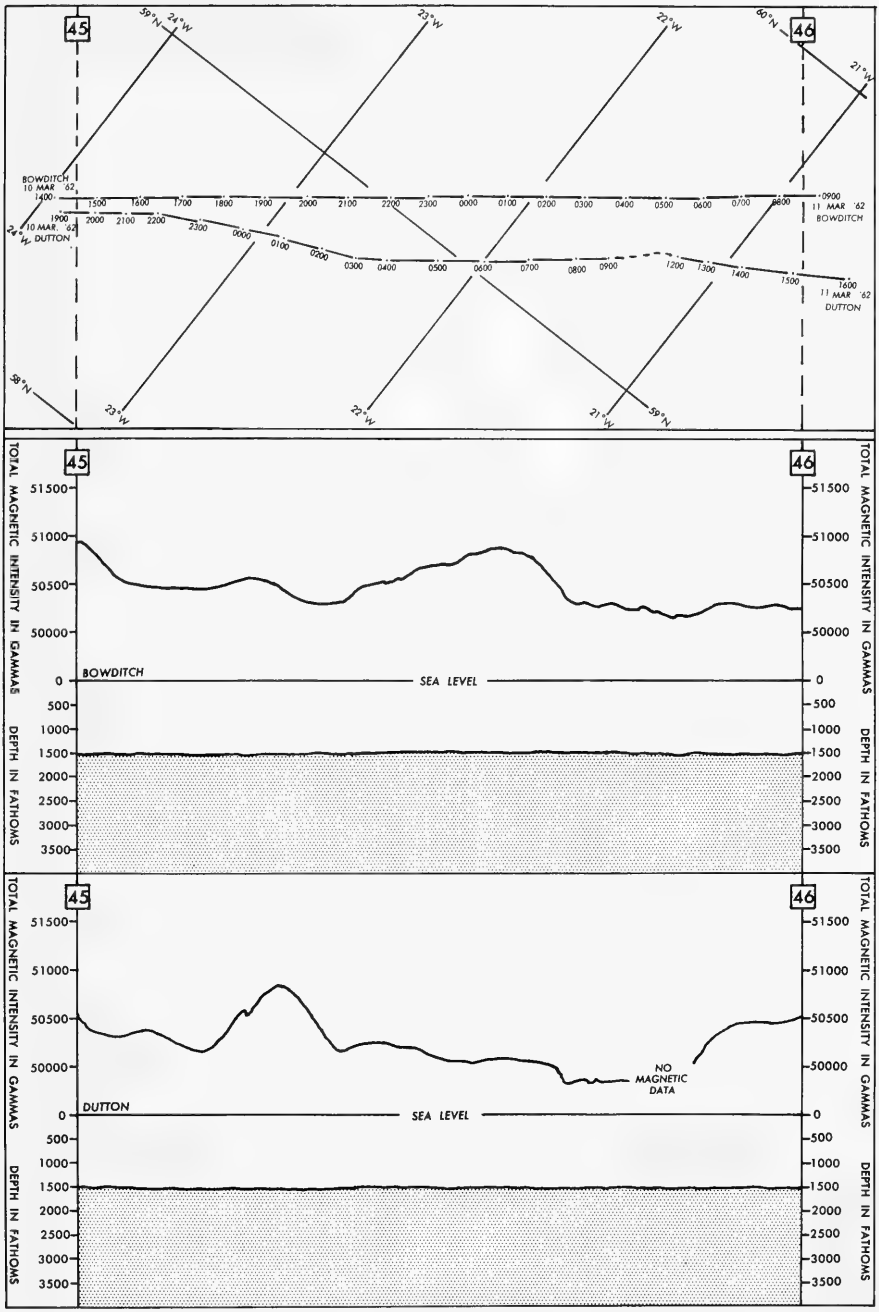


FIGURE 47.— MAGNETIC AND BATHYMETRIC PROFILES 45-46

10 5 0 10 20 30 NAUTICAL MILES

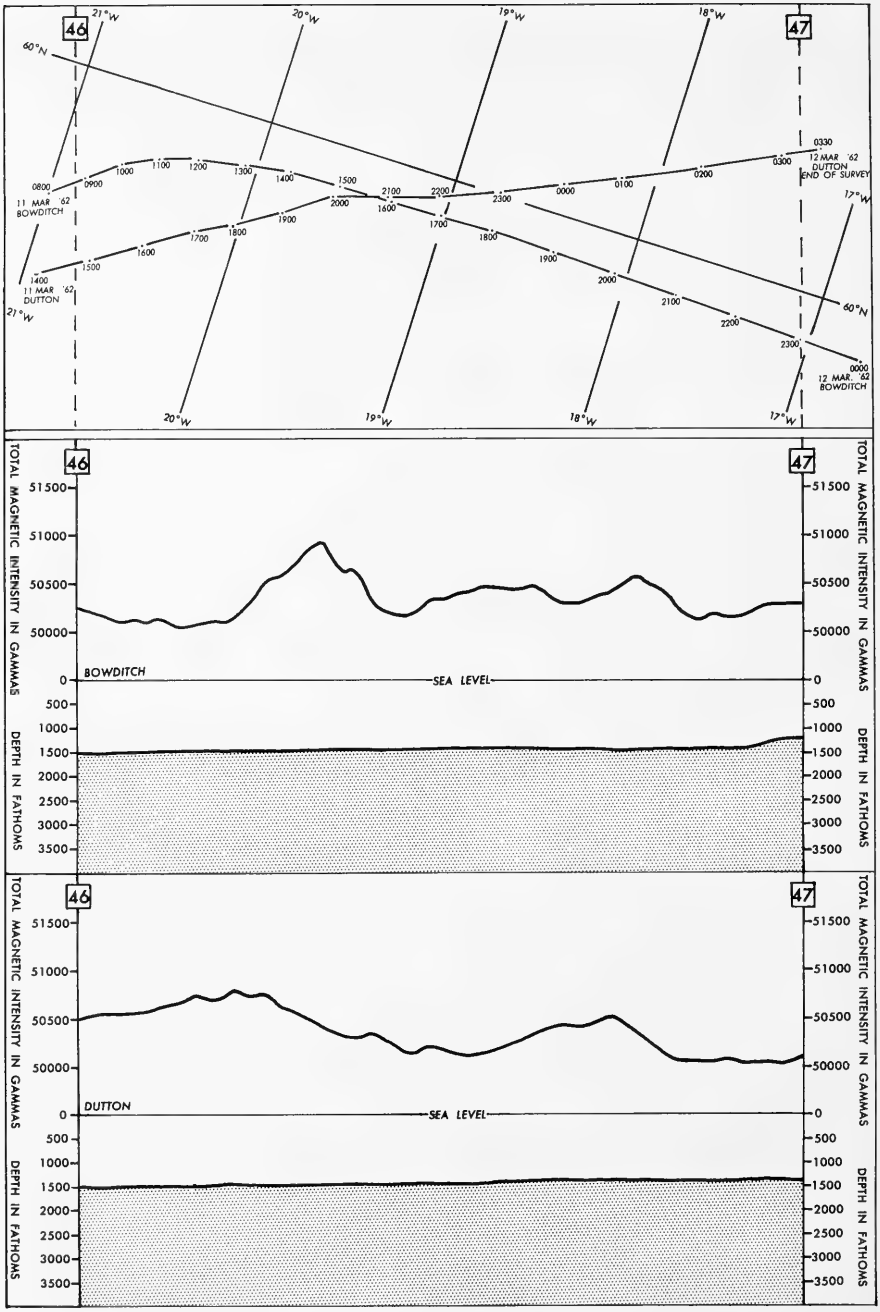


FIGURE 48.— MAGNETIC AND BATHYMETRIC PROFILES 46-47

10 5 0 10 20 30 NAUTICAL MILES

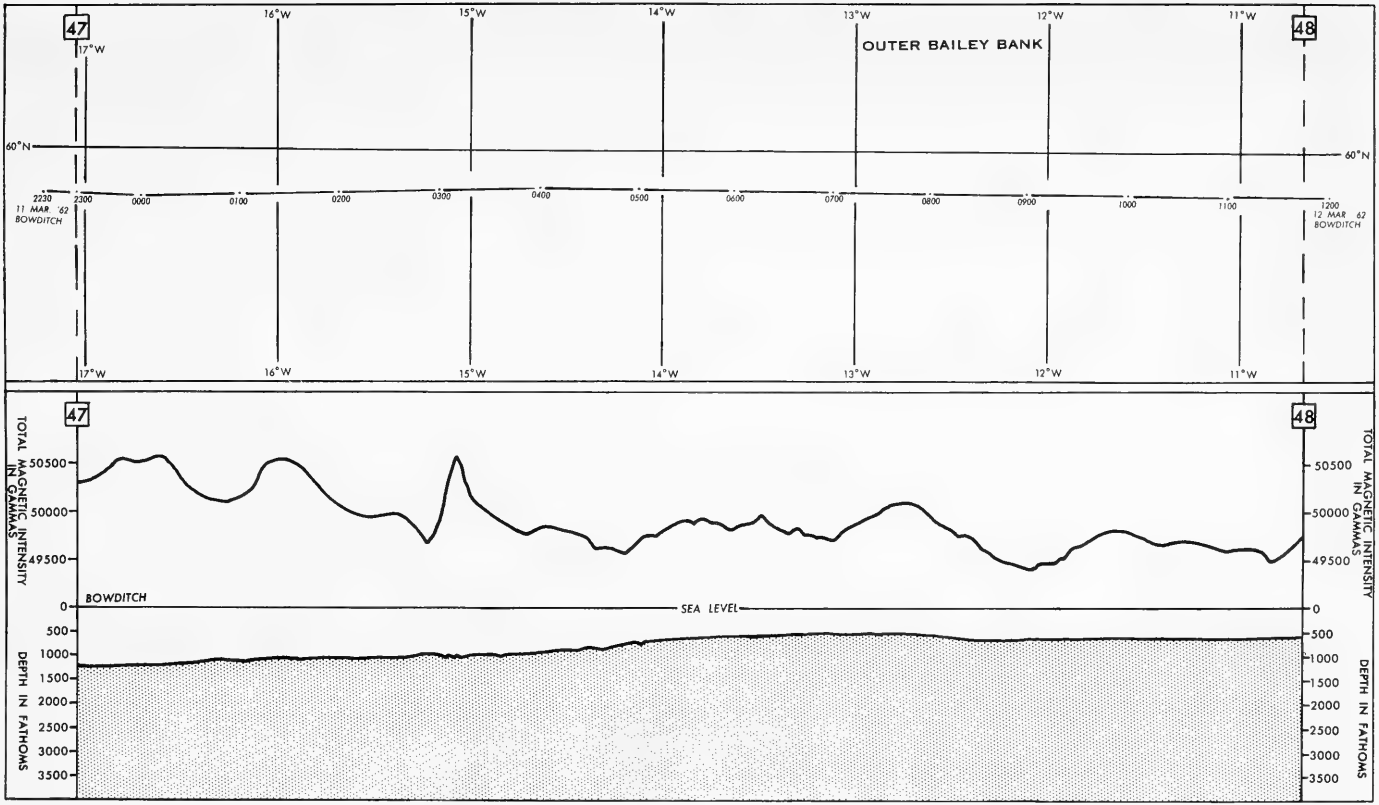


FIGURE 49.— MAGNETIC AND BATHYMETRIC PROFILES 47-48

10 5 0 10 20 30 NAUTICAL MILES

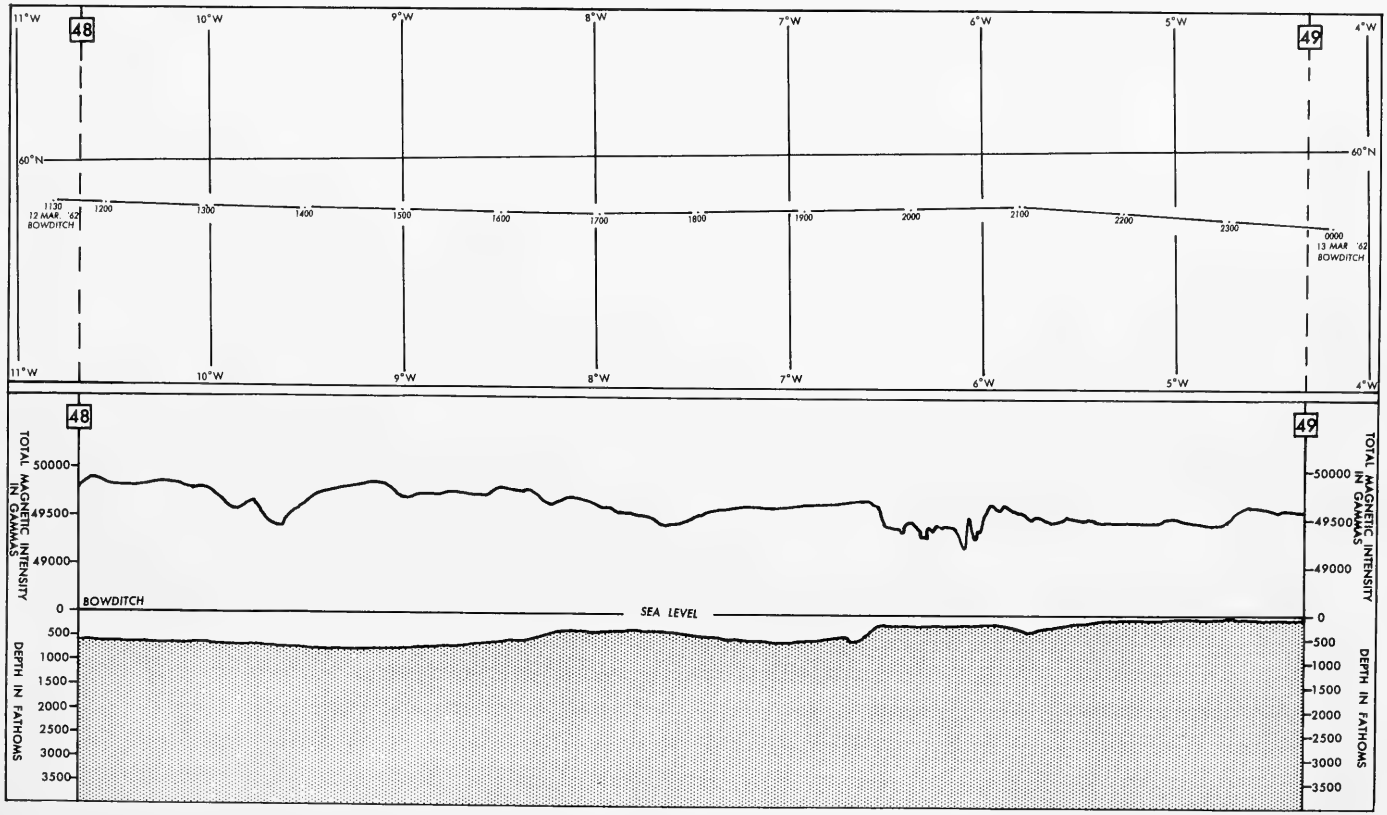


FIGURE 50.— MAGNETIC AND BATHYMETRIC PROFILES 48-49

10 5 0 10 20 30 NAUTICAL MILES

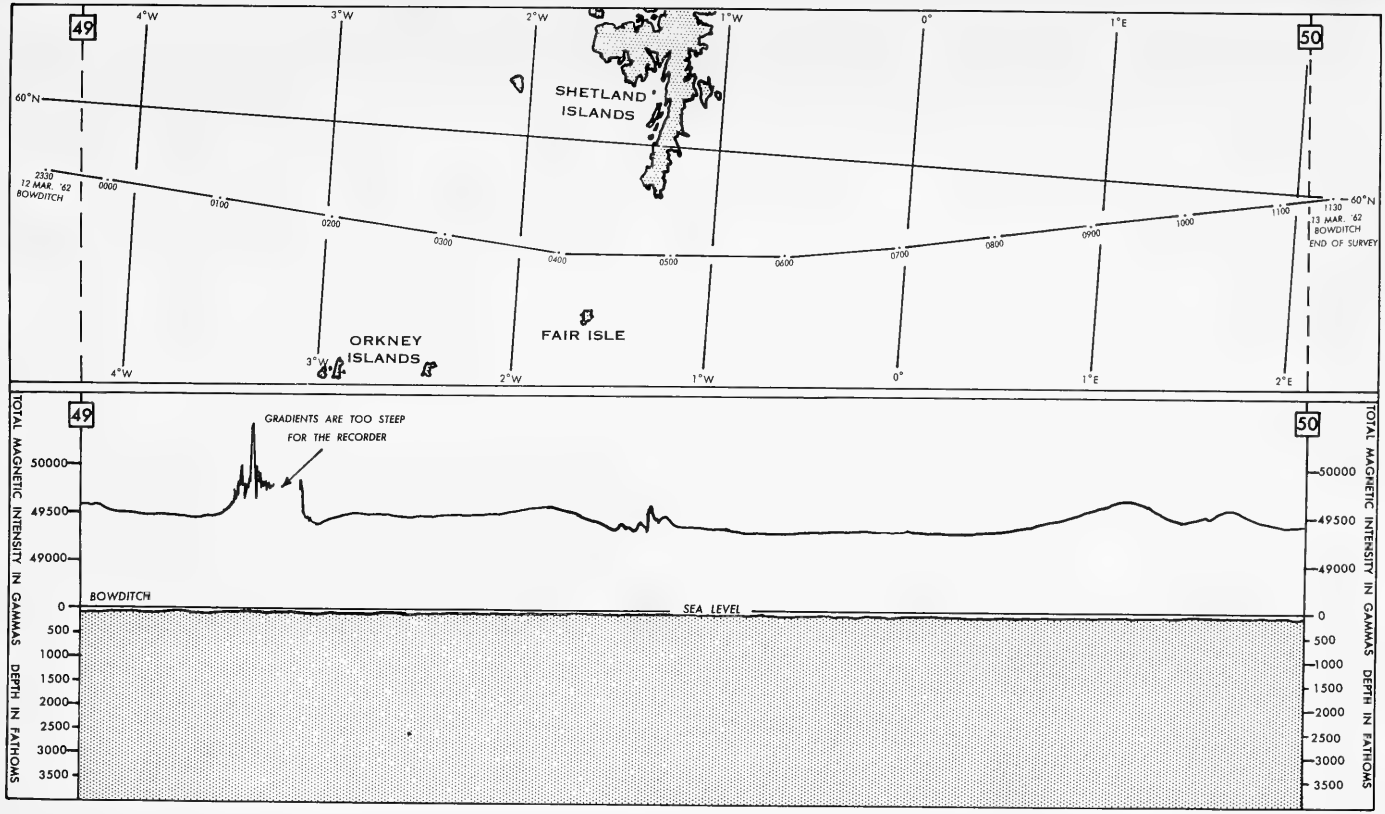


FIGURE 51.— MAGNETIC AND BATHYMETRIC PROFILES 49-50

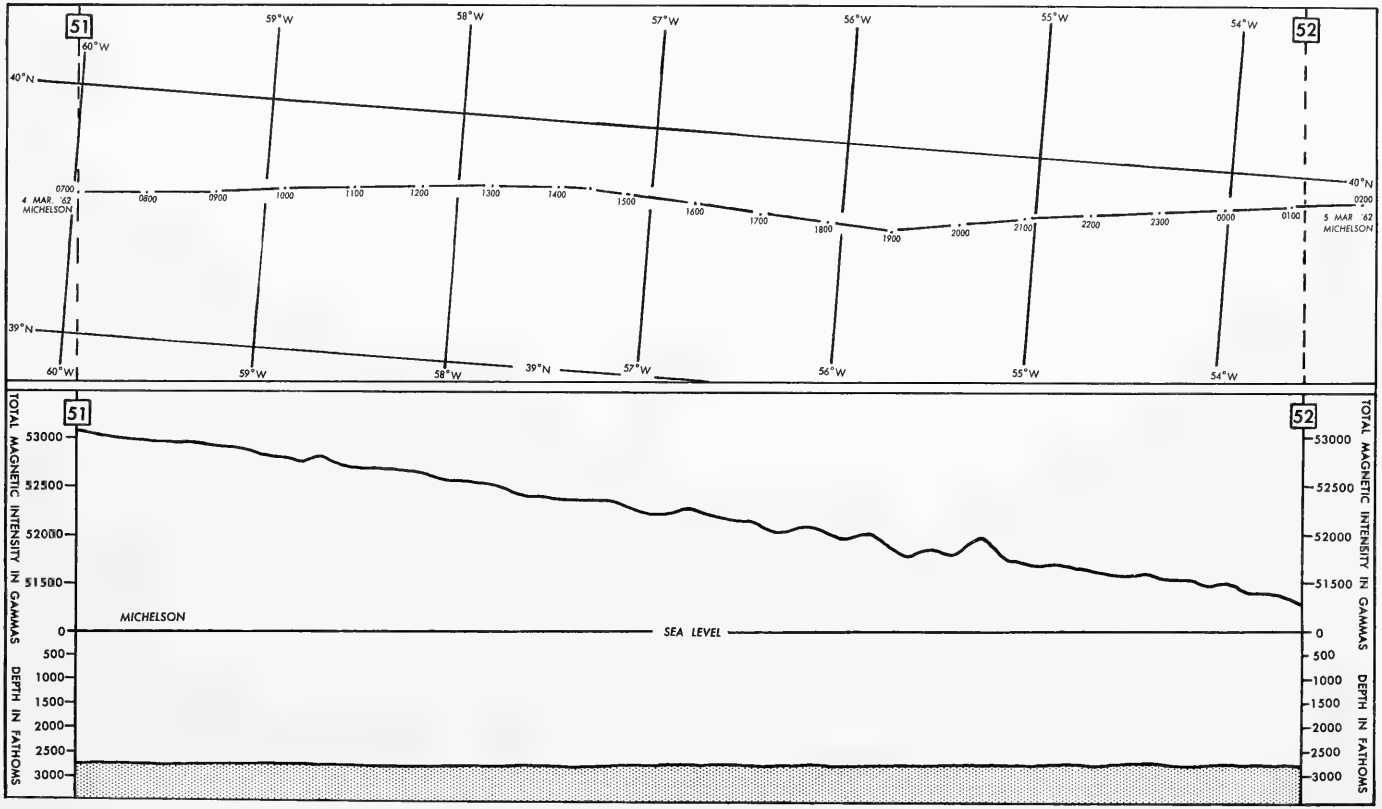


FIGURE 52.— MAGNETIC AND BATHYMETRIC PROFILES 51-52

10 5 0 10 20 30 NAUTICAL MILES

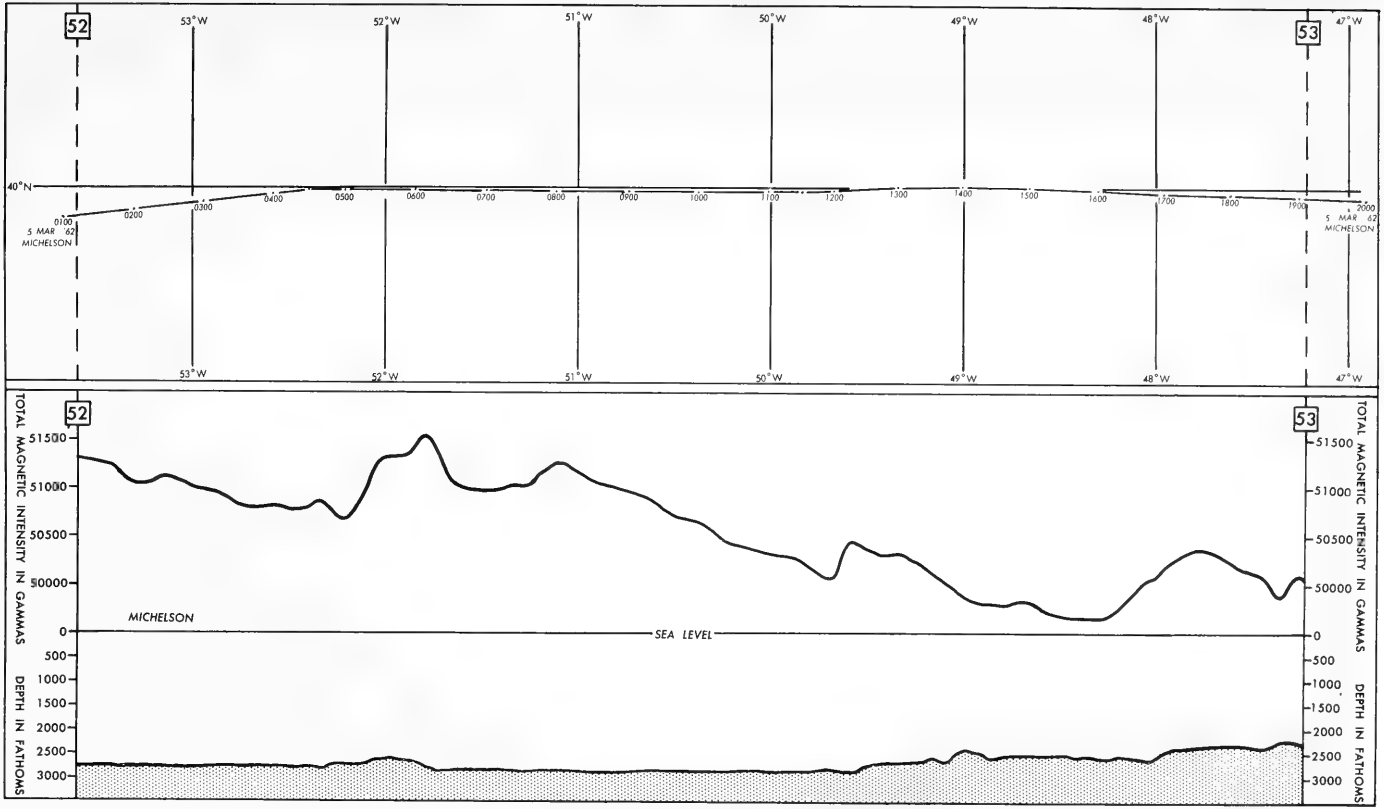


FIGURE 53.— MAGNETIC AND BATHYMETRIC PROFILES 52-53

10 5 0 10 20 30 NAUTICAL MILES

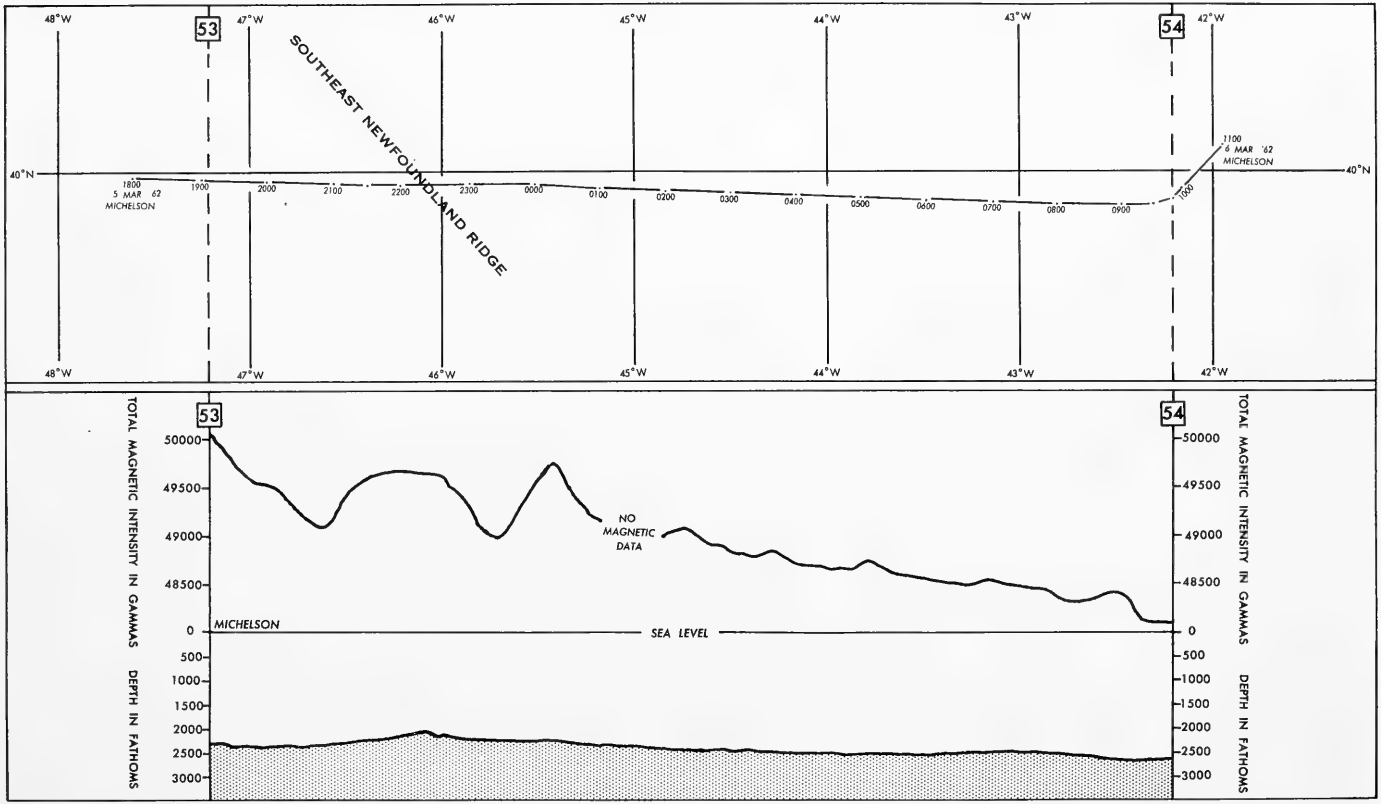


FIGURE 54.— MAGNETIC AND BATHYMETRIC PROFILES 53-54

10 5 0 10 20 30

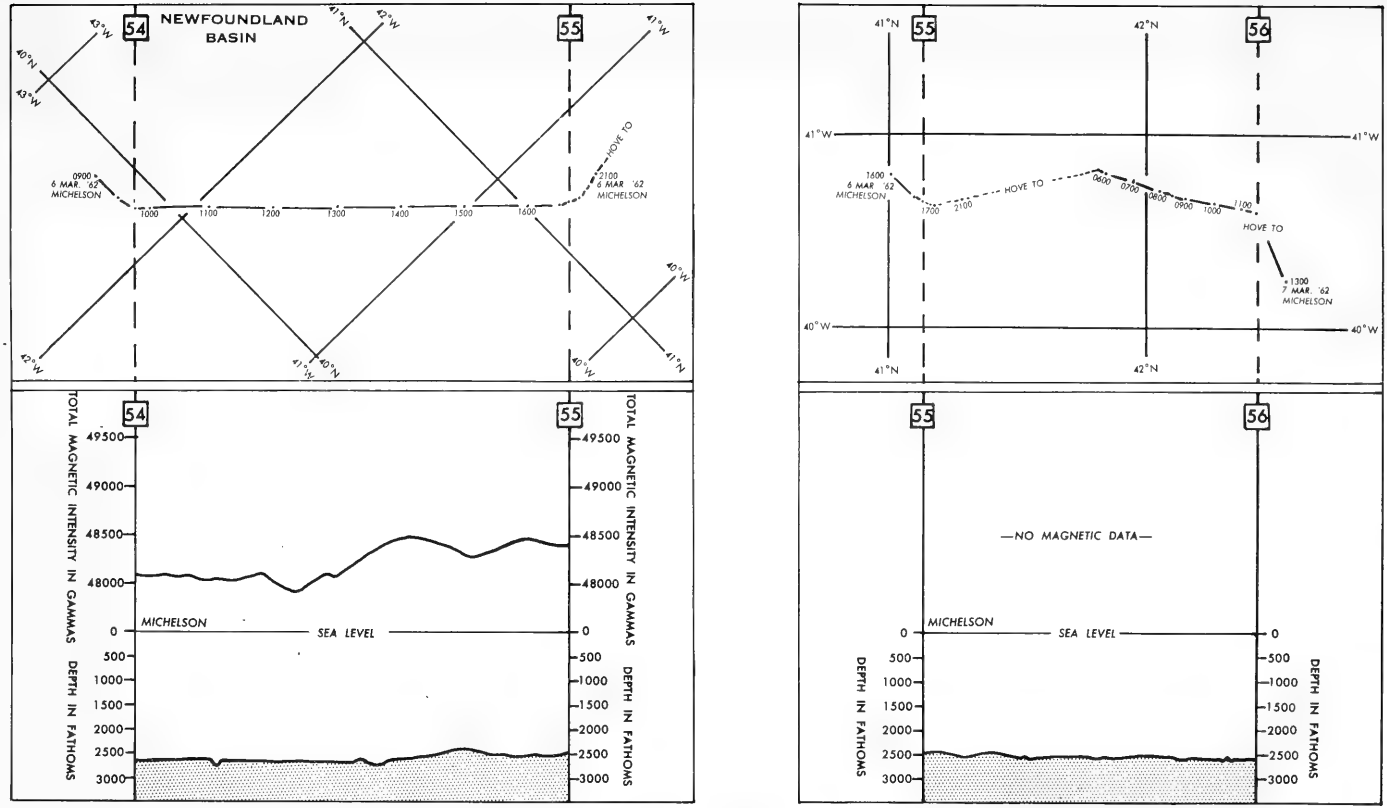


FIGURE 55.— MAGNETIC AND BATHYMETRIC PROFILES 54-55 AND 55-56

10 5 0 10 20 30 NAUTICAL MILES

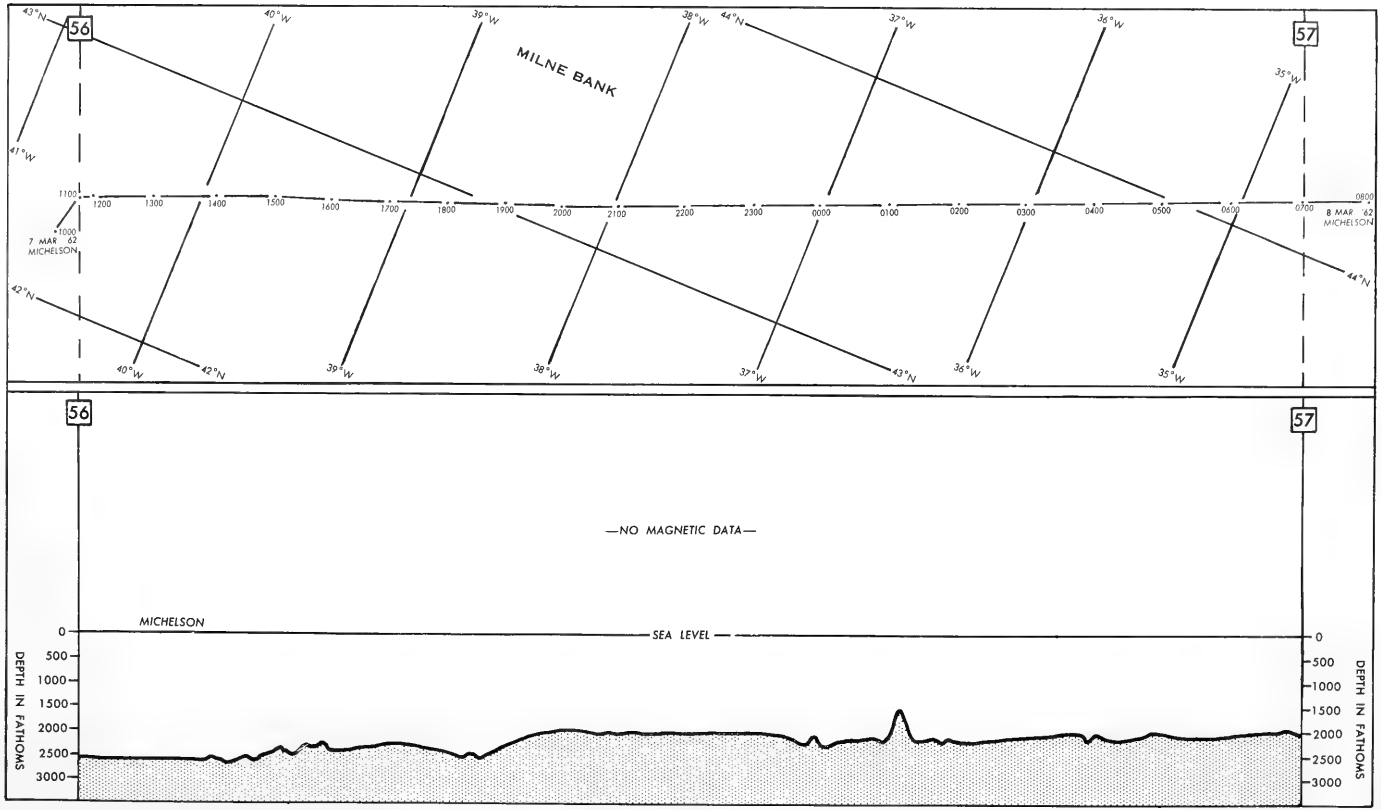


FIGURE 56.— MAGNETIC AND BATHYMETRIC PROFILES 56-57

10 5 0 10 20 30 NAUTICAL MILES

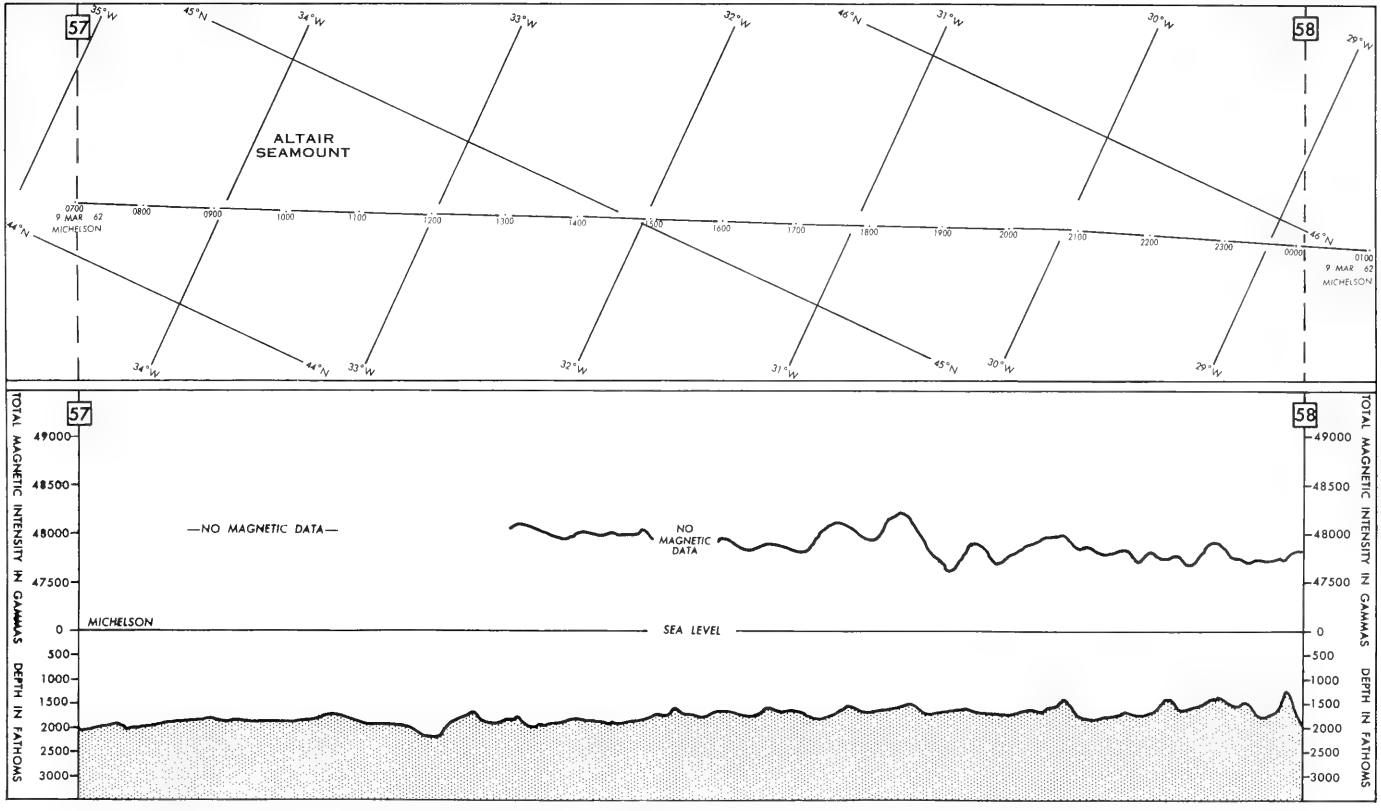


FIGURE 57.— MAGNETIC AND BATHYMETRIC PROFILES 57-58

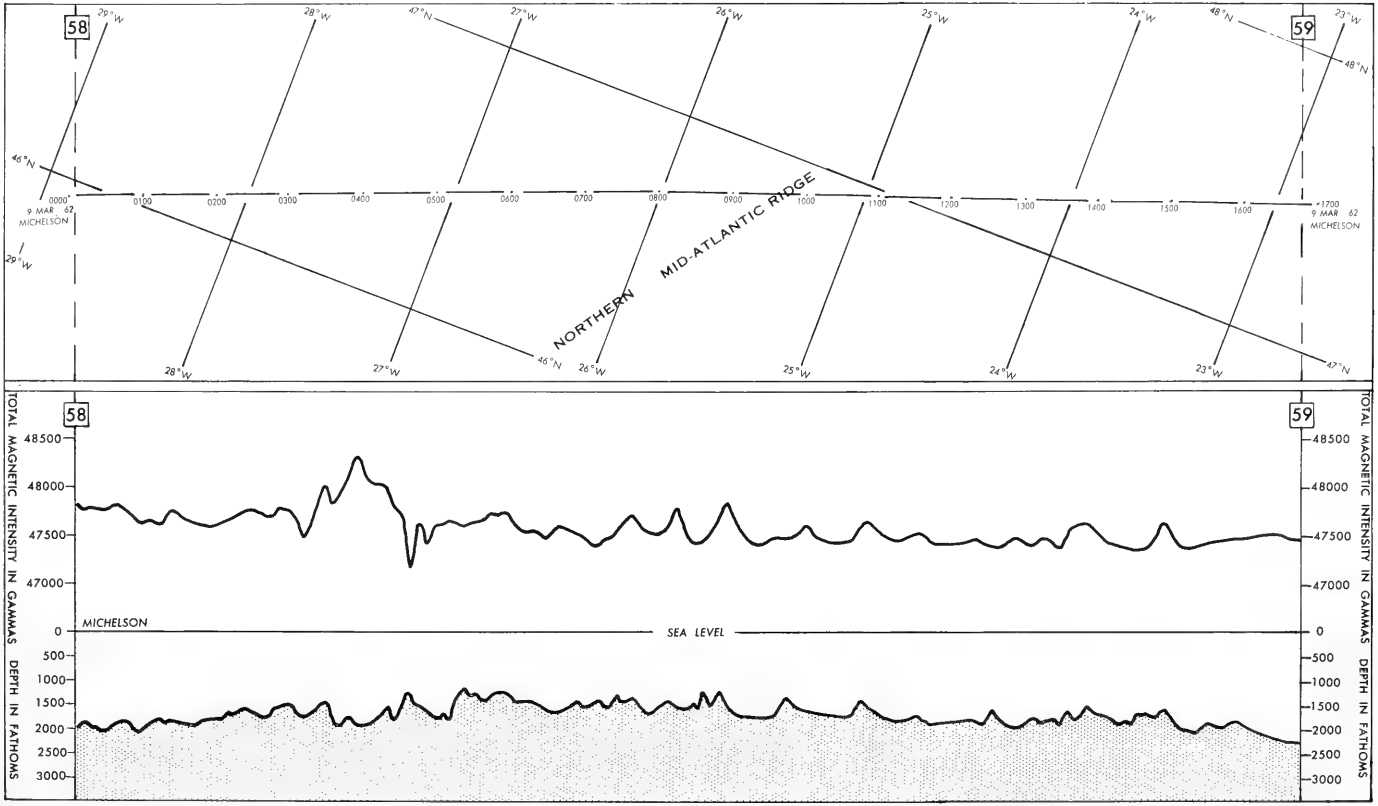


FIGURE 58.— MAGNETIC AND BATHYMETRIC PROFILES 58-59

10 5 0 10 20 30 NAUTICAL MILES

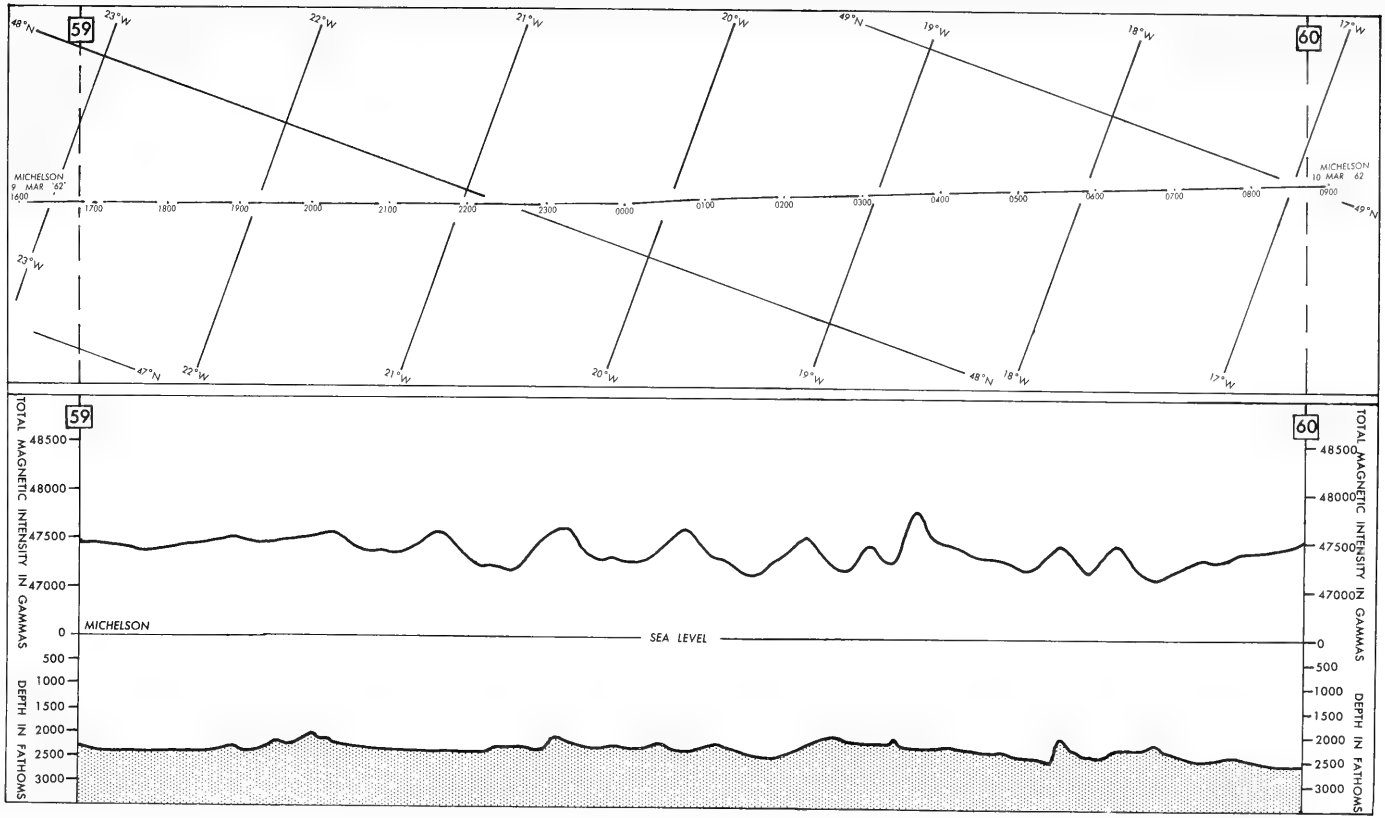


FIGURE 59.— MAGNETIC AND BATHYMETRIC PROFILES 59-60

10 5 0 10 20 30 NAUTICAL MILES

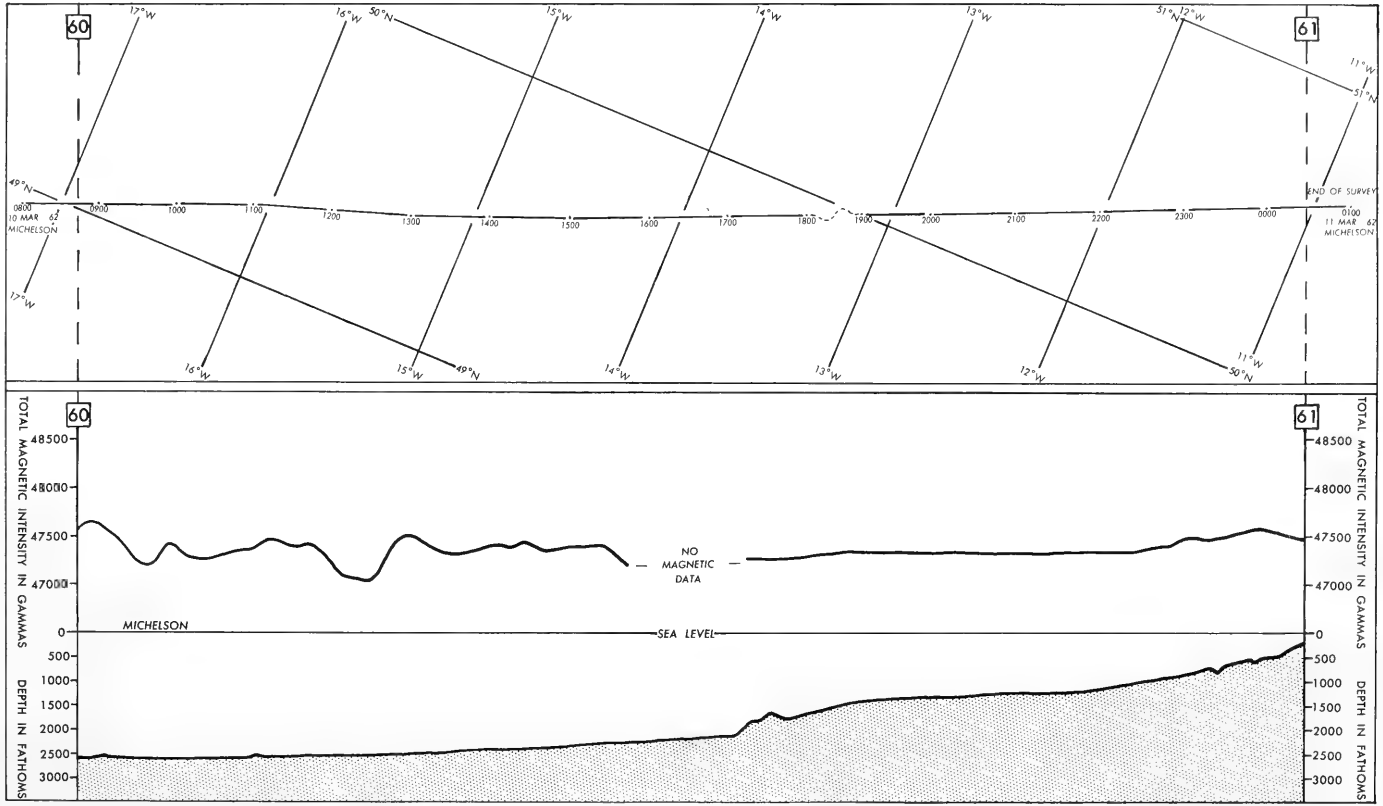


FIGURE 60.— MAGNETIC AND BATHYMETRIC PROFILES 60-61

10 5 0 10 20 30 NAUTICAL MILES

U. S. Naval Oceanographic Office
GEOMAGNETIC AND BATHYMETRIC PROFILES ACROSS THE NORTH ATLANTIC OCEAN, November 1963. 74 p. including 60 figs. (TR-161).

Presents geomagnetic and bathymetric profiles from two North Atlantic crossings between New York and the Norwegian Sea during multi-ship survey operations. A combined total of 17,200 miles was surveyed on six trans-oceanic tracks.

1. Magnetism, Terrestrial-Atlantic Ocean
2. Atlantic Ocean

i. Title: Geomagnetic and Bathymetric Profiles Across the North Atlantic Ocean
ii. Author: Otis E. Avery
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